

ANNALS of SURGERY

A MONTHLY REVIEW OF
SURGICAL SCIENCE AND
PRACTICE

Edited by

Lewis Stephen Pilcher, M.D., LL.D., of New York

Associate Editors

W. Sampson Handley, M.S., M.D., F.R.C.S., of London

James Taft Pilcher, B.A., M.D., of New York

Walter Estell Lee, M.D., of Philadelphia

*THE OFFICIAL PUBLICATION of the
AMERICAN SURGICAL ASSOCIATION
of the NEW YORK SURGICAL SOCIETY and the
PHILADELPHIA ACADEMY OF SURGERY*

Volume XCVI

July--December

1932

Philadelphia & London

J. B. LIPPINCOTT COMPANY

COPYRIGHT 1932 BY
J. B. LIPPINCOTT COMPANY

MADE IN THE UNITED STATES OF AMERICA

CONTRIBUTORS TO VOLUME XCVI

	PAGE
ABRAMSON, PAUL D., Shreveport, La.....	49
ADSON, ALFRED W., Rochester, Minn.....	771
ALLEN, ARTHUR W., Boston, Mass.....	867
ANDREWS, EDMUND, Chicago, Ill.....	40, 615
BACHE, WILLIAM, Sayre, Pa.....	796
BAILEY, FRED WARREN, St. Louis, Mo.....	530
BAILEY, HUGH A., Baltimore, Md.....	537
BALFOUR, DONALD C., Rochester, Minn.....	581
BALLIN, MAX, Detroit, Mich.....	649
BANCROFT, FREDERIC W., New York, N. Y.....	1036
BEER, EDWIN, New York, N. Y.....	687
BEHREND, MOSES, Philadelphia, Pa.....	159
BERNHEIM, BERTRAM M., Baltimore, Md.....	179
BERRY, FRANK B., New York, N. Y.....	961
BEST, R. RUSSELL, Omaha, Neb.....	184
BEVAN, ARTHUR DEAN, Chicago, Ill.....	555
BIRNBAUM, I. R., Akron, Ohio.....	470
BLALOCK, ALFRED, Nashville, Tenn.....	36
BLOODGOOD, JOSEPH COLT, Baltimore, Md.....	882
BOOKMYER, R. H., Detroit, Mich.....	413
BRUCE, HERBERT A., Toronto, Canada.....	864
BUCHANAN, EDWIN PORTER, Pittsburgh, Pa.....	359
CAMPBELL, WILLIS C., Memphis, Tenn.....	1055
CARSON, WILLIAM J., Milwaukee, Wis.....	157
CARTER, RUPERT FRANKLIN, New York, N. Y.....	94
CAVE, HENRY W., New York, N. Y.....	269
CHEEVER, DAVID, Boston, Mass.....	911
CHILDS, EDWARD P., New York, N. Y.....	961
CLURMAN, MORRIS J., Brooklyn, N. Y.....	480
CLUTE, HOWARD M., Boston, Mass.....	385
COLLER, FREDERICK A., Ann Arbor, Mich.....	719
COLLINS, DONALD C., Rochester, Minn.....	1044
CONNELL, F. GREGORY, Oshkosh, Wis.....	200
COOKE, H. HAMILTON, Lowville, N. Y.....	321
COOPERMAN, MORRIS B., Philadelphia, Pa.....	1065
CURTIS, LAWRENCE, Philadelphia, Pa.....	979
DANDY, WALTER E., Baltimore, Md.....	787
DAVID, VERNON C., Chicago, Ill.....	381
DAVIS, JAMES E., Detroit, Mich.....	413
DAY, LOIS, Chicago, Ill.....	595
DE TAKATS, GEZA, Chicago, Ill.....	418
DONALD, JOSEPH M., Rochester, Minn.....	1028
DOSTAL, L. E., Chicago, Ill.....	615
DUFFIELD, WARREN L., Brooklyn, N. Y.....	98
EGGERS, CARL, New York, N. Y.....	1098
ELIASON, ELDRIDGE L., Philadelphia, Pa.....	27, 801
ELLIOTT, JR., ELLSWORTH, New York, N. Y.....	1117
ESTES, JR., WILLIAM L., Bethlehem, Pa.....	250, 924
FERGUSON, L. K., Philadelphia, Pa.....	801
FOSS, HAROLD L., Danville, Pa.....	857
FRASER, JOHN, Edinburgh, Scotland.....	488
FRIEDENWALD, JONAS S., Baltimore, Md.....	995
FULD, JOSEPH E., New York, N. Y.....	160
GALLIE, WILLIAM EDWARD, Toronto, Canada.....	551
GARSDIE, EARL, Chicago, Ill.....	691
GATEWOOD, GATEWOOD, Chicago, Ill.....	588
GIBBON, JOHN H., Philadelphia, Pa.....	102
GILL, A. BRUCE, Philadelphia, Pa.....	I

CONTRIBUTORS TO VOLUME XCVI

	PAGE
GINZBURG, LEON, New York, N. Y.....	368, 478
GOFF, M., Chicago, Ill.....	615
GOLDBERG, SAMUEL L., Rochester, Minn.....	156
GOLDBLATT, DAVID, New York, N. Y.....	1083
GRACE, RODERICK V., New York, N. Y.....	973
GRAHAM, A. STEPHENS, Rochester, Minn.....	625
GRAHAM, GEORGE S., Birmingham, Ala.....	893
GRAHAM, HENRY F., Brooklyn, N. Y.....	155
GUTHRIE, DONALD, Sayre, Pa.....	796
HALE, KELLEY, Wilmington, Ohio.....	474
HARKINS, HENRY, Chicago, Ill.....	40
HARRINGTON, STUART W., Rochester, Minn.....	843
HARRISON, JR., W. GROCE, Nashville, Tenn.....	36
HARVEY, SAMUEL C., New Haven, Conn.....	744
HASTINGS, A. BAIRD, Chicago, Ill.....	595
HEEKS, WILLIAM G., New York, N. Y.....	930
HENTZ, VICTOR G., New York, N. Y.....	456
HEUER, GEORGE J., Cincinnati, Ohio.....	830
HICKEN, N. FREDERICK, Cleveland, Ohio.....	998
HIGGINS, CHARLES C., Cleveland, Ohio.....	998
HINTON, J. WILLIAM, New York, N. Y.....	441
HOLM, C. E., Bethlehem, Pa.....	924
HORSLEY, J. SHELTON, Richmond, Va.....	515
HRDINA, L., Chicago, Ill.....	615
HUNT, VERNE C., Los Angeles, Calif.....	210
IVY, ROBERT H., Philadelphia, Pa.....	979
JEFFRIES, JOHN W., Philadelphia, Pa.....	215
JONES, HAROLD WELLINGTON, Sam Houston, Texas.....	85
JUDD, E. STARR, Rochester, Minn.....	1028
KLEIN, JACOB E., Chicago, Ill.....	1032
KLINGENSTEIN, PERCY, New York, N. Y.....	286
LAROCQUE, G. PAUL, Richmond, Va.....	240
LESTER, CHARLES W., New York, N. Y.....	1036
LEWISOHN, RICHARD, New York, N. Y.....	447
LINTON, ROBERT R., Boston, Mass.....	394
LORIA, FRANK L., New Orleans, La.....	169
MACKENZIE, WALLACE D., Chicago, Ill.....	418
MADDOCK, WALTER G., Ann Arbor, Minn.....	719
MARTIN, JOHN D., Atlanta, Ga.....	462
MARTIN, WALTON, New York, N. Y.....	930
MASON, JAMES M., Birmingham, Ala.....	893
MATHEWS, FRANK S., New York, N. Y.....	871
MAYO, CHARLES H., Rochester, Minn.....	481
MAYO, WILLIAM J., Rochester, Minn.....	771
MCCAUGHAN, JOHN M., Rochester, Minn.....	1103
MEYER, WILLY, New York, N. Y.....	891
MITCHELL, JOSEPH I., Memphis, Tenn.....	1055
MIXTER, CHARLES G., Boston, Mass.....	1017
MOORHEAD, JOHN J., New York, N. Y.....	17
MORTON, JOHN J., Rochester, N. Y.....	754
MOSCHCOWITZ, ALEXIS V., New York, N. Y.....	575
MUELLER, R. STERLING, New York, N. Y.....	364
NEUHOF, HAROLD, New York, N. Y.....	44
OCHSNER, ALTON, New Orleans, La.....	691
ORATOR, VICTOR, Duesseldorf, Germany.....	184
OUGHTERSON, ASHLEY W., New Haven, Conn.....	744
OWEN, MAY, Fort Worth, Texas.....	472
PATTERSON, HOWARD ALEXANDER, New York, N. Y.....	1091
PEARSE, JR., HERMAN E., Rochester, N. Y.....	192
PEMBERTON, JOHN DEJ., Rochester, Minn.....	1103
PENICK, JR., RAWLEY M., Baltimore, Md.....	219
PETERSON, EDWARD W., New York, N. Y.....	94, 340
PHEMISTER, DALLAS B., Chicago, Ill.....	595
PILCHER, LEWIS S., Brooklyn, N. Y.....	1114
POTTER, PHILIP C., New York, N. Y.....	364

CONTRIBUTORS TO VOLUME XCVI

	PAGE
PRIESTLY, JOSEPH B., Rochester, Minn.....	1014
RABINOWITCH, I. M., Montreal, Canada.....	70
RANKIN, FRED W., Rochester, Minn.....	625
REID, MONT R., Cincinnati, Ohio.....	733
RENTSCHLER, CALVIN B., Reading, Pa.....	987
RICHTER, HELEN G., New Haven, Conn.....	744
ROBERTSON, DAVID E., Toronto, Canada.....	767
SARGENT, WILLARD S., U. S. Navy.....	464
SARNOFF, JACOB, Brooklyn, N. Y.....	466
SCHWYZER, ARNOLD, St. Paul, Minn.....	666
SCOTT, W. J. MERLE, Rochester N. Y.....	754
SEELEY, SAM F., Manila, P. I.....	350
SELINGER, JEROME, New York, N. Y.....	204
SHIFLETT, E. LEE, Richmond, Va.....	240
SHIPLEY, ARTHUR M., Baltimore, Md.....	537
SINGER, HARRY A., Chicago, Ill.....	230
SMITH, ARTHUR MORTON, Cleveland, Ohio.....	292
SPEED, KELLOGG, Chicago, Ill.....	951
STEINBERG, BERNHARD, Toledo, Ohio.....	451
STEPHENS, HOWARD W., San Francisco, Calif.....	1078
STEWART, JOHN D., Boston, Mass.....	225
STONE, HARVEY B., Baltimore, Md.....	683
VAUGHAN, ROGER T., Chicago, Ill.....	230
VEAL, J. ROSS, Boston, Mass.....	385
WALTERS, WALTMAN, Rochester, Minn.....	258, 1014
WARFIELD, JR., J. OGLE, Washington, D. C.....	329
WARTHEN, JR., HARRY J., Baltimore, Md.....	515
WEEKS, CARNES, New York, N. Y.....	973
WHITE, RICHARD JOSEPH, Fort Worth, Tex.....	472
WHITMAN, ARMITAGE, New York, N. Y.....	1049
WILLIS, BYRD CHARLES, Rocky Mount, N. C.....	161
WOLFSON, WILLIAM L., Brooklyn, N. Y.....	480
WRIGHT, ROBERT B., Baltimore, Md.....	75
ZINNINGER, MAX M., Cincinnati, Ohio.....	406

LIPPINCOTT BOOKS

Piersol's Anatomy

J. B. LIPPINCOTT CO.

BURNS

\$5.00

By GEORGE T. PACK, B.S., M.D., and A. HOBSON DAVIS, B.S., M.D. 364 pages. 60 illustrations.

Because of the greatly increased occurrence of burns in the more and more complicated fields of industry, the subject becomes a crucial import to every practitioner. The very wide group of materials which in one way or another cause burns is augmenting daily. The fact that in all industries inflammable and explosive agents are in constant usage, often by unskilled and careless workmen, obligates the profession to acquaint itself with the subject in its widely and diversified forms and particularly as to the prompt and most satisfactory method of treatment demanded in each special instance. The author of this book from his detailed knowledge both from practical experience and intensive study of the literature of the subject is particularly qualified to write in this field.

UROLOGY

Second Edition

\$11.00

By DANIEL N. EISENERATH, M.D., Attending Urologist, Michael Reese and Chicago Memorial Hospitals, and HARRY C. ROLNICK, M.D., Associate Urologist, Mt. Sinai Hospital. 942 pages. 710 illustrations.

Presents the subject in the simplest possible manner. Covers the diagnosis and treatment of diseases of the urinary and genital tracts as well as venereal diseases, and takes up as thoroughly as possible the diseases of the male genitalia.

FRACTURES AND DISLOCATIONS—Treatment and After-Care

Second Edition

\$11.00

By PHILIP D. WILSON, Instructor in Surgery, Harvard Medical School, and WILLIAM A. COCHRANE, Associated with SIR HAROLD STILES, Edinburgh. 789 pages. 1029 illustrations.

Describes all methods, old or new, which have proved of the greatest value. Many photographs of actual cases and drawings show the best ways of handling every condition that arises in the treatment and after-care of all fractures and dislocations, particularly stressing the restoration of function.

RADIUM IN GYNECOLOGY

\$8.00

By JOHN G. CLARK, M.D., Gynecologist-in-Chief to the University Hospital, Philadelphia, and CHARLES C. NORRIS, M.D., Prof. of Obstetrics and Gynecology, University of Pennsylvania, and Gynecologist to the Radiologic Staff of the Philadelphia General Hospital. 315 pages. 49 illustrations.

This complete and splendidly illustrated book is absolutely essential to any surgeon working in the gynecologic field. The status of radium therapy is now definitely established. Almost complete absence of mortality and the practical certainty of cures far surpass the operative results or any other kind of therapy.

OFFICE SURGERY

\$5.00

By FENWICK BECKMAN, Clinical Professor of Surgery, New York University and Bellevue Medical College. This work cannot fail to be of great assistance to any practitioner who is called upon for office surgical treatments, for surgical diagnosis or for meeting the important surgical emergencies which come so frequently to every practitioner.

APPLIED ANATOMY

Eighth Edition

\$10.00

By GWILYM G. DAVIS, 638 pages. 656 illustrations in colors and black.

This new edition, revised by Dr. George P. Muller, University of Pennsylvania, brings the book strictly up to date. It is a classic whose usefulness will be greatly increased by the revision.

J. B. LIPPINCOTT COMPANY

London, Since 1875

Philadelphia, Since 1792

Montreal, Since 1897

LIPPINCOTT BOOKS

ANNALS *of* SURGERY

Vol. XCVI

JULY, 1932

No. 1

TREATMENT OF FRACTURES OF THE NECK OF THE FEMUR*

BY A. BRUCE GILL, M.D.

OF PHILADELPHIA, PA.

A CLOSE study of the statistics pertaining to the treatment of fractures of the neck of the femur available in the literature very quickly reveals that a rigid comparison of the results obtained by various methods of treatment by different surgeons and in different clinics is not possible. Results are not tabulated in a uniform fashion. The cases in some series were apparently selected and in others included all that came to the hospital or the clinic. This fact alone must make a great difference in the percentage rate of the mortality and the end-results of treatment. The term "good functional result" may not always mean the same thing. Percentage of bony union is not often given.

Extracapsular, or intertrochanteric, fractures must be excluded, as it is well known that with proper treatment they always unite.

The age of the patient at the time of the fracture is of great importance. Union occurs much more frequently under sixty years than it does beyond this age. A fair comparison of the end-results of different methods of treatment is impossible unless the statistics permit us to divide the cases into at least these two groups.

But age is not the only consideration in the probability of union. While fractures of the femoral neck are rare in the young and common in the aged, why do some fractures unite and others not unite in individuals of the same age treated by the same method? Bone degenerative processes occur in the head and the neck of the femur with advancing years, or for other reasons, which increase the fragility of the bone and render repair more difficult. We frequently see evidences of a degenerative arthritis of the hip developing after a fracture. Is it not probable that these processes had already begun before the fracture occurred and that they have a direct etiological bearing on it.

It would be of interest if surgeons and röntgenologists would make note of such conditions present at the time of fracture.

Causes of Non-Union.—Before we can evaluate any method of treatment we should have some knowledge of the factors which tend to promote or prevent union of a fracture of the femoral neck.

(1) *Incomplete Reduction of the Fracture.*—One of the most frequent causes of non-union (omitting the consideration of those too frequent cases

* Read before the Philadelphia Academy of Surgery, November 2, 1931.

where no reduction at all has been made) is the interposition of soft parts between the fragments. Schmorl states that interposition of synovia prevented union in 75 per cent. of his cases. Wilson made a careful dissection in nine cases of non-union and found interposition of soft tissue in eight of them. In five, the capsule was adherent to the anteverted raw surface of the distal fragment; in two, it was densely bound to the distal portion of the proximal fragment; and in one, it was constricted between the fragments. Campbell mentions that the psoas tendon may be caught between the fragments. The author has repeatedly in his operations on old ununited fractures found the capsule adherent to the fractured surface of the proximal fragment, particularly at its inferior aspect, and frequently also adherent to the distal fractured surface.

Furthermore, on manipulation of a fractured hip there is a tendency for the short proximal fragment to rotate in the acetabulum. There is nothing to fix it.

(2) *Injury to Blood-supply with Necrosis of the Head.*—The main blood-supply to the head is derived from the capsular arteries which enter the base of the neck. It has been commonly believed that the ligamentum teres carries small vessels to the head in early life but that these vessels disappear after growth is attained. Recently, Schmorl and others have shown in serial sections of the ligamentum teres that the vessels are at times active even in old age. But it is conceded that these small vessels may be insufficient to nourish the femoral head when the vessels that enter it from the neck have been cut off by a fracture.

An injected specimen (*Acta Orthopædica Scandinavica*, vol. i, p. 3, 1930) demonstrates beautifully the arteries coursing through the neck apparently largely just beneath the periosteum and synovia and entering the head and anastomosing there, but it fails to show any penetrating the head in the region of the round ligament. The author has many times cut the ligamentum teres in operations for fracture of the neck of the femur and in operations for congenital dislocation of the hip, and he has never noticed any blood coming from either end of it. On removing the head in cases of non-union he has frequently observed that the round ligament is much degenerated. It is yellow and soft.

It seems probable, therefore, that at the time of the fracture the proximal fragment immediately is completely or almost completely deprived of its blood-supply. Of course, it must undergo death and aseptic necrosis unless the blood-supply becomes reëstablished. Impaction either by the force of the accident or by the surgeon at the time of reduction probably aids in early entrance of new vessels into the proximal fragment. Interposition of soft tissue or separation of the fragments prevents it. Possibly the head in some cases of old fracture has been receiving partial nourishment through the capsule which has become adherent to it.

But, certain it is, that in many cases of non-union the head is dead and is undergoing necrotic changes. This is demonstrable in the X-ray films.

Such a head is relatively more dense than the bone of the distal fragment. As pointed out by Santos and Phemister, the distal fragment undergoes an atrophy of disuse and some of its lime salts are carried away in the bloodstream. The lime salts in the proximal fragment cannot be carried away because there is no circulation in it. The head, therefore, retains its original density in the X-ray film for a period of many months.

(3) *Absence of Normal Osteogenesis*.—What are the conditions which determine union or non-union following the fracture of any bone, and to what extent are these conditions present or absent in fractures of the neck of the femur?

When a fracture occurs in the shaft of a long bone, according to Leriche, there is first a congestion of the soft tissues about the fracture, a slowing down of the blood-supply, then a deposit in these tissues of a pre-osseous substance, followed by a conversion of this pre-osseous material into callus through the deposition of lime salts. He was unable to determine the biochemical process through which this conversion occurs. Recent laboratory studies seem to throw some light on this obscure process. An enzyme, called phosphatase, found in bones, in the kidney and elsewhere, appears to play the rôle of workman in using the materials furnished by the blood—namely, calcium and phosphorus—to construct bone. Studies now being made show that the amount of phosphatase varies greatly in conditions of disease and health. Are some cases of non-union of bones generally to be explained by a deficiency of this enzyme? Bricks and mortar may be present, but the workman may be absent. Numerous studies in blood chemistry in cases of non-union of bone indicate that the absence of union is not due to lack of calcium and phosphorus in the blood. It is well known that in such conditions as osteogenesis imperfecta and osteomalacia, while there is a great lack of lime salts in the bones, the multiple and successive fractures which occur usually heal readily.

There are no soft tissues about the neck of the femur in which preosseous material can form; and the periosteum is not a prominent structure as on the shafts of long bones, if we grant that periosteum and osteoblasts have anything to do with bone formation; and the blood-supply to the head and neck of the femur comes through the bone itself and not from surrounding soft tissues.

Whether or not the presence of synovial fluid about the fracture has anything to do with union or non-union we do not yet know. Some observers think the head may receive a slight amount of nourishment from the fluid, others think the fluid may be detrimental to the formation of callus.

However, since callus can be formed alone from the distal fragment, where alone there is life, any slight motion of the fragments after reduction will break up the callus very easily.

It is, therefore, very obvious that the question of union or non-union of a fracture of the femoral neck is a complicated one and some of the factors are still obscure. In estimating the worth of any method of treatment we

must rely on imperfect statistics and on our conception of how effectively the method meets the conditions mentioned above.

But it will be evident from this study that some fractures do not unite by any method of treatment. Certain ones seem doomed to failure of union from the moment of the accident, either because of serious injury to the blood-supply or because of some more obscure reason for defective osteogenesis. May it be possible to recognize this type of case early in its history in order to avoid prolonged but hopeless treatment?

In addition to these particular cases of non-union we will be confronted with a far larger number in which the failure of union has been due to unsuitable or improper treatment of the fresh fracture. What shall we do for these patients? Shall we let them alone or operate on them? If we operate, how shall we decide whether to attempt to secure union by a bone graft, or by the Brackett operation, or by fixation with some foreign body; or, on the other hand, to give up all thought of union and do a Lorenz bifurcation operation, or remove the head alone as advised by Sir Robert Jones, or combine this procedure with a reconstruction operation as devised by Whitman or Albee?

If we try for union, we will have a certain percentage of failures in securing good anatomical and functional results. A reconstruction operation is then imperative.

But if we go one step farther in our inquiry and ask what are the results of a reconstruction operation, we shall discover that here, too, we have failed to cure all of our patients. We have not given to all a stable, painless, and freely movable hip. We have failed to restore some of these long-enduring and long-suffering souls to a useful and happy life. We have cured not even their pain. And here the literature leaves us. We have reached the end.

The whole picture seems to be rather gloomy and dismal. First of all, there is a high mortality in fractures of the neck of the femur. Under the best non-operative methods of treatment we may expect bony union in not more than 50 to 60 per cent. and in a much smaller percentage than that in patients over sixty years of age. We treat the patient by taking him off his feet for from six months to a year and then we discover that he cannot use his hip. He consents to a bone-peg operation and lies in a plaster cast for three months and then uses crutches and a brace for another six months or more and is unable to throw them away. He eventually returns to the hospital a third time and we make him a new joint. At the end of another six months he may be walking and he thinks that at last the surgeon has cured him. But after the years have passed, be they few or many, his old enemy, pain, grips him again by the hip. He has developed an osteo-arthritis in his false, and I might say hollow, joint. It is a hollow joint—the femur has not stayed in the socket.

Non-Operative Treatment.—But I draw too sad a picture. Surgery has accomplished much in recent years. Sir Astley Paston Cooper believed that fractures of the olecranon, the patella, and the neck of the femur do not unite

by bone. Oscar Allis, in comparatively recent times, stated that we cannot hope for bony union in fractures of the femoral neck.

A British fracture commission about twenty years ago stated that only 22 per cent. of cases treated by the older conventional methods secured a good result judged even by weight-bearing standards, and that in thirty-six cases over sixty years of age only five had a good result (13.8 per cent.). Sir Robert Jones states that Katzensteen, in a report made to the Surgical Society of Berlin, in 1928, asserted that in 119 cases of transcervical fracture only 11.5 per cent. secured good results by conventional methods of treatment.

Walker, in 1914, reported results obtained in the treatment of 112 cases in the Bellevue Hospital in New York during the years 1906 and 1907, and stated that in only 13 per cent. were good results obtained.

These figures may be considered as fairly representative of the conventional methods of treating fractures of the neck of the femur before the Whitman abduction method became generally recognized and acknowledged to be a distinct advance in the handling of this fracture. The acceptance of the Whitman method marks a new epoch in the heretofore dreary history of this condition. The statistics thereafter begin to show a decided improvement. The author has carefully reviewed all articles published in the English language during the past fifteen to twenty years, and from these selects the following statistics as being fairly representative:

Dorrance, in 1918, reported eleven cases treated by the Whitman method with but one failure. In 1920, the same author, in conjunction with Murphy, reported twenty cases with good results in 45 per cent., fair results in 15 per cent. and bad results in 25 per cent.

Powers, in 1922, reported twenty-two cases with 93 per cent. good results. Campbell, in 1919, and again in 1923, reported series of cases with 90 per cent. good results. Ashhurst and Crossan, in 1926, reported 43 per cent. good and 37 per cent. fair results. Löfberg and Waldenström have obtained bony union in 80 per cent. of a large series of cases. Higgs, in the 1927 Proceedings of the Royal Society of Medicine, reported five cases treated by the Whitman method with good results in all, and six cases treated by extension with 100 per cent. failure in securing union.

On the other hand, Janecke, in 1922, in the *Beitr. z. klin. Chir.*, reported 123 cases treated by extension, of whom 66 per cent. had a usable hip. Hey-Groves, in 1930, reported 42 per cent. good and 22 per cent. fair and 26 per cent. poor results in 116 cases.

Reggio, in the October, 1930, issue of the *Journal of Bone and Joint Surgery*, published a very careful study, one of the most painstaking and complete to be found in the literature, of end-results of all cases treated in the fracture service of the Massachusetts General Hospital during the years 1921 to 1927. Forty-nine cases were treated by the Whitman method and twenty-one by other methods. Omitting the dead and the cases in which results were unknown, the Whitman method gave 60 per cent. good, 16.6 per cent. fair and 23.4 per cent. bad results. Union occurred in 80 per cent. In treatment by other methods, good results were obtained in 36.4 per cent., fair in 18.3 per cent. and bad in 45.4 per cent. Union was obtained in only 45.4 per cent. The mortality was practically alike in both series of cases, about 25 per cent. for the entire group and about 30 per cent. if unknown cases are omitted.

Reports of the fracture commission of the American Orthopædic Association made in 1929 and 1930 contain the following: In a study of 201 cases over sixty years of age the percentage of proved bony union was 30.4 per cent., and the percentage of entirely

satisfactory results was 50.4 per cent. A second series of 365 cases under sixty years of age showed 51.9 per cent. proved bony union and satisfactory end-results in 57.7 per cent. Practically all had been treated by the Whitman method.

Other methods of treatment, such as the Maxwell-Ruth method, have their present-day advocates, but we have no statistics whereby we may fairly judge of the end-results secured by them, and we must hold them for the present *sub judice*.

Making due allowance for the faults of statistical tables, and granting that some surgeons because of their greater expertness in manipulation and in putting on plaster cases may get better results than others, it is still evident that the use of the Whitman method has given vastly better results than the older methods of treatment and that good end-results may be expected on a general average in 50 per cent. to 65 per cent. of cases.

We must remember, however, that the age of the patient has a tremendous bearing on the mortality and on the result that may be obtained by any method of treatment.

Wilson, in his series, had no deaths in patients under fifty years. Between fifty and sixty years, the mortality was 18 per cent. in sixteen cases; between sixty and seventy years, 28 per cent. in thirty-two cases; between seventy and eighty years, 54 per cent. in twenty-four cases; over eighty years, 100 per cent. in eight cases; 40 per cent. in all cases. Bony union occurred in 80 per cent. under fifty years, between fifty and sixty years, 18 per cent.; between sixty and seventy years, 38 per cent.; and not one of seven surviving patients between seventy and eighty years got bony union.

Dorrance stated that we should not expect bony union in patients over sixty-five years of age.

Reggio's figures under Whitman treatment (omitting dead and unknown) are as follows:

Age—Years	No. Cases	Mortality	Good Results
Under 50	9	0.0 per cent	87.5 per cent
50-60	13	15.0 per cent	62.5 per cent
60-70	7	30.0 per cent	60. per cent
70-80	18	44.0 per cent	37.5 per cent
80-83	2	50.0 per cent	0.0 per cent

The total mortality figures vary greatly from 6 per cent. to as high as 41 per cent. Stebbins (*Brit. Jour. Surg.*, 1927) cites 111 cases with forty-six deaths, thirty-one of which occurred without leaving the hospital, seven within thirty days after leaving, and eight lived six months and two for over a year. Wilson's rate is 40 per cent. mortality. Löffberg gives 6 per cent. These discrepancies can probably be accounted for by the fact that some patients are too ill to undergo treatment and die without treatment. These have probably been excluded from certain statistics giving results of treatment. Reggio's total mortality was 26 per cent. A fair average of all cases may be assumed to be possibly 20 per cent. to 25 per cent.

Open Reduction and Internal Fixation of Fresh Fractures.—In recent years, there has been a growing inclination among a few surgeons to operate on selected cases of fresh fractures of the neck of the femur; and in one clinic, the fracture service of the Massachusetts General Hospital, Doctor Smith-Petersen has been doing an open reduction and driving in his special nail to secure accurate and effective internal fixation in a group of older cases. Other surgeons have used bone-pegs, plates and nails.

FRACTURES OF THE NECK OF FEMUR

The advantages claimed for the operative procedure are that accurate apposition is obtained, certainly conducive to early and good union, and that the time spent in bed and in the hospital is greatly shortened. These patients are able to bear weight early and their period of disability is greatly shortened. These advantages, if true, are not lightly to be considered. The shortening of the period of disability among wage earners under sixty years of age is of vast importance. If, in addition, it gives a greater percentage of bony union than do non-operative methods, it should be the method of choice by capable surgeons unless the dangers of the operation outweigh its manifest advantages.

Unfortunately, no published statistics have been found. I have received the following personal communication from Smith-Petersen:

<i>Age of Patients:</i>		<i>Duration of Fractures:</i>	
20 to 30 years.....	2	I	10 months non-union
30 to 40 years.....	2	I	15 months non-union
40 to 50 years.....	2	I	19 months non-union
50 to 60 years.....	9	I	2½ years non-union
60 to 70 years.....	7		
70 to 80 years.....	1		
80 to 90 years.....	1		

In three of these non-union cases bony union was obtained. The fourth case, that of two and a half years' duration, had an excellent functional result when last seen, five and a half months after operation, but the bony union was questionable. She is one of the cases classified in the end-result table as having no end-result. The fact that bony union has been achieved in so many of these cases of non-union of long duration speaks well for the method.

In four of the twenty-four cases treated no end-result has been recorded since it was impossible to get in touch with the patients. The end-results of the remaining twenty cases are as follows: Bony union, 15, 75 per cent. Non-union, 3, 15 per cent. Deaths, 2, 10 per cent.

Nine of his twenty-four cases of recent fracture were over sixty years of age and nine more were between fifty and sixty years. Six were under fifty. His figures do not allow us to analyze the results according to the age of the patient. His mortality is no higher than might be expected from any form of treatment. In fact, it is much lower than the general average, but his group of cases was doubtless selected. Bad surgical risks were probably not operated on. It is reported that his patients have little or no shock and pain. This is entirely credible.

The author's experience in eighteen operations for ununited fractures of the neck of the femur and in more than two hundred other operations on the hip-joint for various conditions has been that surgical shock is practically negligible and that there has been but one death, and that one because of a re-kindled infection in a case of old osteomyelitis.

The use of an autogenous bone-peg for internal fixation necessitates a second operative procedure and probably adds to the risk. No statistics are available for its use in fresh fractures.

Certainly open operation gives us far better facility to control the movement of the head, to remove interposing soft tissue and to secure accurate apposition and impaction of the fragments than does any closed method of treatment. It seems probable that it will never come into general use for the treatment of all fractures of the femoral neck, but that capable surgeons accustomed to operating upon the hip will employ it more frequently in cases that are good surgical risks.

Treatment of Ununited Fractures.—In considering the treatment of non-union one must first decide whether to let the patient alone or to operate on him. Many cases, particularly among the aged, are not suitable cases for any operation. Henderson, of The Mayo Clinic, reports one series of 120 cases of which only twenty-six were operated on. Of these twenty-six, only ten resulted in bony union and good function, 8.3 per cent. of the total number of cases. Generally speaking, most patients under sixty years of age may be offered hope of improvement by some type of operation and many patients beyond this age period may fall in the same category. But each case must be decided on its own merits. Some patients may not seem to be good operative risks, but operation is more or less imperative to relieve them of pain which is slowly but surely killing them. They prefer any risk to their present condition of pain and helplessness.

The surgeon must next decide whether to attempt to secure union or whether, by a reconstruction operation, to sacrifice the head of the femur and hope to obtain a painless, movable and stable hip.

If he decides upon the former procedure, he is offered a choice of methods of operation. But it is essential in all of them that he should remove all soft tissue from the fractured surfaces of the two fragments and from between them, that he should freshen these surfaces, place the fragments in close contact with proper alignment and maintain their accurate position by internal or external fixation or by both, until union has occurred.

If the distal surface of the head of the femur is concave and flush with the rim of the acetabulum, as the author has observed it to be at times, and if the neck is completely absorbed and the shaft is also concave in shape where the neck had been present, it is impossible to secure contact of the two fragments except by using the Brackett operation.

If the proximal fragment is not viable, union should not be expected. Possibly, at times, union may occur after operation even when the head is a piece of dead bone. Vessels may grow from the freshened surface of the distal fragment into the dead bone or grow along an autogenous bone-graft and rejuvenate the head or a portion of it. But it is very questionable whether this process can be complete. This theory may account for those cases which appear to get bony union but which a year or two later show a collapse of the head. Santos and Phemister suppose that weight-bearing

FRACTURES OF THE NECK OF FEMUR

was allowed too early. I am inclined to believe such collapse would occur anyway because of incomplete reestablishment of circulation in the head, and defective regeneration of its bony structure.

Some cases of recent fracture which are well treated, have had good reduction and firm fixation, fail to unite. More or less rapid absorption of the neck occurs. Is it because the blood-supply has been so seriously injured at the time of the accident or by subsequent thrombosis that it cannot be reestablished, or is there some more obscure reason for the complete breakdown of osteogenesis? However, whatever the cause may be, it does not seem reasonable to suppose that we can do by operation what nature has failed to do under the best possible conditions.

Therefore, the author believes it to be unsafe to attempt to secure union in those cases which have shown rapid or complete absorption of the neck, in those in which the X-ray gives evidence of the death of the proximal fragment, and in those which, at the time of operation, present gross evidence of the death and degeneration of the head. Some proximal fragments are dry like the pith of an elderberry branch; some have only a thin, fragile cortex of bone, while the interior consists of a soft, degenerated tissue which can be scooped out with the finger. In many the articular cartilage of the head has largely disappeared. None of them bleed when dug up with a gouge.

In 1925, Albee stated that 90 per cent. of old fractures require a reconstruction operation and but 10 per cent. are suitable for a bone-peg operation. In 1928, he revised that statement in the light of his end-results and asserted that a greater per cent. are suitable for the bone-peg operation. In 1929, he reported end-results in 228 cases with an excellent result in 90 per cent. of the bone-graft operations and in 75 per cent. of the reconstruction operations.

Henderson states that the bone-peg operation should not be done on patients over fifty-five years of age, or in others who have had a marked absorption of the femoral neck.

Ellis Jones states that he secured good functional results in 90 per cent. of his bone-peg operations in twenty-one cases and good results in seventeen cases of Whitman reconstruction operation. But in the aged a reconstruction operation is inevitably followed by osteo-arthritic changes which make the hip increasingly painful. He believes that the Robert Jones operation of excision of the head through a posterior incision, followed by a long period of freedom from weight-bearing with a caliper splint gives as good results as any reconstruction operation. The bone-peg operation when successful gives the best functional results. He believes the radiograph is not a sure criterion in judging the viability of the head.

The author's experience with the Whitman reconstruction operation has not been happy. He has found that the end of the femur does not remain in the acetabulum. According to the simple law of mechanics whereby a force directed obliquely against a hard surface is divided into two components, the thrust of the straight femur against the oblique acetabulum must expend itself partly in a direction at a right angle to the plane of the acetabulum and partly in a direction parallel with the plane of the acetabulum. The

latter tends to force the femur out of the acetabulum. Furthermore, any degree of adduction of the femur by increasing the angle of incidence increases the outward thrust. In the normal femur the angulation of the neck with the shaft lessens the angle of incidence and maintains the head more securely in the acetabulum.

As the femur slips upward after a reconstruction operation it rests against the upper rim of the acetabulum. This margin may enlarge to meet the increased demand upon it or it may break down completely. The latter is more apt to occur in the older patients. The acetabulum gradually becomes obliterated and the weight of the body is borne largely by the sloping side of the pelvis and the soft tissues. Osteo-arthritic changes become apparent in many cases. Mechanically, these cases strongly resemble old cases of congenital dislocation of the hip. It is well known that unilateral cases of dislocation may lead practically a normal life for many years without pain. Eventually, however, as they get older some of them at least become incapacitated by pain.

Mechanically, therefore, a reconstructed hip does not appear to be adapted to long-continued and normal function. Youth may adapt itself to the altered conditions of weight-bearing, but age is slow to change, and changes, when they occur, are apt to be retrogressive.

Albee (Jour. Bone and Joint Surg., October, 1928) cites thirteen cases of reconstruction with excellent results. Eight of these were under fifty years of age, three were in the fifties, and two in the sixties. The cuts illustrating the paper show end-results in two cases, one sixty-seven years of age and the other forty-four years of age. Both illustrations emphasize the points I have just made. In the former, the femur stands out beyond the pelvis and only the inferior part of the base of the neck appears to be in contact with the upper rim of the socket; and in the latter, the acetabulum is obliterated, the upper margin of the acetabulum is hypertrophied, and the great trochanter seems to have worn a false acetabulum on the side of the pelvis.

The author may appear rash in criticizing the reconstruction operation, but mechanically it does not appear sound and clinically it has not given good results in his hands.

The Lorenz bifurcation operation has been used somewhat in Europe with favorable outcome. The author has had no experience with it and has not found any definite statistical reports on the end-results obtained by it. Sir Robert Jones has recently given his approval to this procedure in proper cases.

And here, as far as the literature is concerned, we have reached the end of our possibilities in the treatment of fractures of the neck of the femur.

Certainly there is a residuum of cases in which all methods of treatment have failed in restoring the function of weight-bearing and in relieving pain. Is there nothing further to be done? Must we accept defeat?

Arthrodesis of the Hip.—Four years ago the author began to employ arthrodesis of the hip in selected cases as a solution to this problem. At first he used it as a last resort when a reconstruction operation had failed. A

little later he performed an arthrodesis in preference to a reconstruction operation. And still later, he has employed it in two cases of fracture but three months old which in that brief time had undergone practically complete absorption of the femoral neck.

It is apparent that a hip ankylosed in good weight-bearing position is far superior to a painful or unstable hip in which motion is present. A patient with a fused hip can engage in all his normal activities of life and do practically everything but lace his own shoe. And, indeed, some learn to do this.

If, therefore, we could secure a firm arthrodesis after all other methods have failed in relieving the patient of pain and disability, we might all agree without argument that the problem had at last been solved, provided the patient survives the many months and even years consumed in the treatment of the fresh fracture, and the subsequent ununited fracture. The shock of operations, the wearing pain he has endured, and his prolonged inactivity have not tended to lengthen his life.

This leads us to inquire whether, if there are some cases doomed to failure of union from the moment of fracture, we might not find some means of recognizing them early in their history and resort at once to an operation which gives promise of their early return to a life of happiness and usefulness.

If, after three or four months of conservative treatment of the fresh fracture, either by a well-executed Whitman abduction manipulation or by open operation with reduction and internal fixation, it is apparent that union is not taking place but that progressive absorption of the neck is occurring, it seems reasonable that we should seriously consider an early arthrodesis of the hip.

What are the difficulties and limitations of arthrodesis of the hip?

The hip-joint, very perversely, frequently becomes ankylosed when we desire to preserve or restore motion, and on the other hand persists in maintaining mobility when we desire ankylosis. Not all operations of arthrodesis are successful in securing bony fusion. Possibly this may be the result of our technic. We may improve our results with more experience. We may also at length discover the reasons why, with the same technic of operation in two cases, one results in success and the other in failure. We cannot avoid the conclusion that the fault may be much more deep-seated than mere method of operation. In some cases, there appears to be an utter lack of callus and new bone formation even when the conditions created by the operation seem to be most favorable for union of the two bones. This is particularly apparent in the case illustrated in Fig. VII. The great trochanter with the outer portion of the shaft of the femur was removed and turned around. The lower end of this transplant was buried in a notch in the pelvis above the acetabulum while the upper end of the transplant was placed again in contact with the shaft of the femur. This graft has united again with the femur but not with the pelvis, and the end of the femur has not fused with the pelvis although both bones had fresh bleeding surfaces when placed in contact at the time of operation.

On the other hand, in Fig. II and Fig. V we see a perfect fusion of femur and pelvis under the same conditions and without the aid of a graft. In Fig. VI we see failure where in the last two cases there was success. There must be some conditions lacking for osteogenesis in these cases which we do not understand. It is not the age of the patient. We have succeeded in a man of sixty-five where we have failed in a man of thirty-nine. If we eventually discover these conditions we may learn why some fractures of the hip do not unite in the first place.

Is there any upward age limit at which we may not hope to secure an arthrodesis of the hip? A larger experience only can answer this question. The one case mentioned above was sixty-five years old at the time of his operation.

Is the operation limited in its application because of its severity? It may be said that the author has seen no instance of shock following it. There has been no mortality. The patients do not suffer any undue amount of pain. Case II was a poor operative risk. The medical men said he had three chances out of ten of coming through the operation alive, because of a damaged heart. But he passed through the operation and the convalescence with no untoward symptoms. He is living today because of the operation, not in spite of it. Relief from constant pain and worry and inactivity has probably lengthened his life. The author always digitalizes his patients by hypodermic injections of digalen over a period of forty-eight hours preceding any major operation.

The objection may be made that since we fail to secure an arthrodesis in some of our cases we still have a minimal residuum of patients who are not cured, and that we are, therefore, no farther advanced in the ultimate solution of the problem than we were before; that it is like an approach toward the infinite—we are always progressing but never reach the end. Answer may be made that we do succeed in our efforts in a fair proportion of cases and that even in our failures we leave them with a much more stable hip than they could possibly have by any reconstruction operation. Case IV failed to get an arthrodesis, yet for three years he has had a painless hip and has worked as a mail-carrier, walking twelve to fourteen miles a day in the discharge of his duties.

This last case makes us inquire whether we might not deepen the upper portion of the acetabulum or reinforce its upper margin and use some method to preserve motion instead of seeking ankylosis.

It is evident from this entire discussion that the last word has not yet been spoken concerning the treatment of fractures of the neck of the femur. Much progress has been made since Whitman announced his revolutionary method of treatment thirty-four years ago, and it is only by our continued interest, our careful observation and research that we may hope to make further advances in treating this surgical condition which has such a high mortality and which strews our professional pathways with so many wrecks.

FRACTURES OF THE NECK OF FEMUR

SUMMARY

(1) Some patients on admission to the hospital are not fit subjects for any treatment directed toward the reduction and fixation of the fracture.

(2) There is a high mortality, probably 25 per cent., when all cases of fracture are included in the statistical tables. The mortality rate increases rapidly beyond the sixtieth year of age.

(3) Non-operative methods of treatment of recent fractures will continue to be used in the majority of cases. Of these the Whitman abduction method has given the best results.

(4) Open operation should be the method of choice in selected cases.

(5) The most common causes of non-union are failure in making a diagnosis of fracture, and improper treatment of cases which have been correctly diagnosed.

But non-union may be expected in 20 to 25 per cent. of cases treated by the Whitman method or by open operation. The rate is low in patients under sixty years and increases rapidly beyond this age.

(6) In ununited fracture, if the head is viable and if a fair portion of the neck has survived, union may be hoped for in 75 per cent. to 90 per cent. by means of an autogenous bone-graft or a Smith-Petersen nail.

(7) Satisfactory union should not be expected in the presence of necrosis of the head, rapid and complete absorption of the neck and in the second class of cases mentioned in item 5, where nature has already failed in osteogenesis under the most favorable conditions that tend to union anywhere and any time.

For this group of cases a reconstruction operation offers a 75 per cent. chance of securing good function in patients under sixty years of age. In patients beyond this age its advantages are very doubtful.

(8) Arthrodesis of the hip affords relief to some patients after any or all of the above-mentioned operations have failed.

If it becomes possible to select early in their history those cases that are doomed to failure of union by any method of treatment, an early arthrodesis will avoid months and years of useless treatment and disability.

CASE REPORTS

CASE I.—J. D., fifty-two years old. Fracture neck of right femur October, 1924. Treated for several weeks in hospital without extension, sand-bags or any other method of fixation. Discharged without being told he had a fracture. Unable to walk since injury except with crutches. Constant pain.

April 29, 1925.—Whitman reconstruction of right hip. Complete absorption of the neck. Head was flush with the margin of the acetabulum. Fractured surface flat and smooth. Concavity present on the side of the femur where the neck should have been. Joint capsule filled with thick, straw-colored fluid containing several loose bodies. Great deal of proliferated and degenerated material apparently coming from synovium. No bleeding from head on being dug with gouge. Bone soft. Gave appearance of fatty degeneration. Bone could be broken easily.

September 21, 1925.—Discharged from hospital. Able to walk well without pain.

October 17, 1931.—Has no pain. Walks with cane, but can walk without. Can lace

his own shoe. Two inches shortening. Walks with external rotation. Cannot be internally rotated beyond mid-position. Fifteen degrees abduction, five degrees adduction present. Flexes thirty degrees beyond right angle. No pain on motion. Patient states that he feels grating in his hip on weight-bearing. Femur can be felt to move up and down slightly on the side of the pelvis. Wears one-inch elevation.

CASE II.—T. G., sixty-three years old. Was thrown from moving train September, 1926. Treated immediately in a Philadelphia hospital with sand-bags, without traction and without abduction. He was discharged in two months as cured.

December 5, 1927.—Has been confined to house since discharge from hospital. Able to move his leg but not to bear weight on it. All motion restricted except internal rotation. One and a half inches shortening. Non-union of neck of femur.

December 7, 1927.—Whitman reconstruction operation.

January 17, 1928.—Case removed. Slight motion without pain.

January 31, 1928.—X-ray examination shows femur riding on edge of acetabulum. Another case applied with thigh in abduction.

March 15, 1928.—No pain. Using crutches. Can bear weight without difficulty. Discharged from hospital.



FIG. 1.

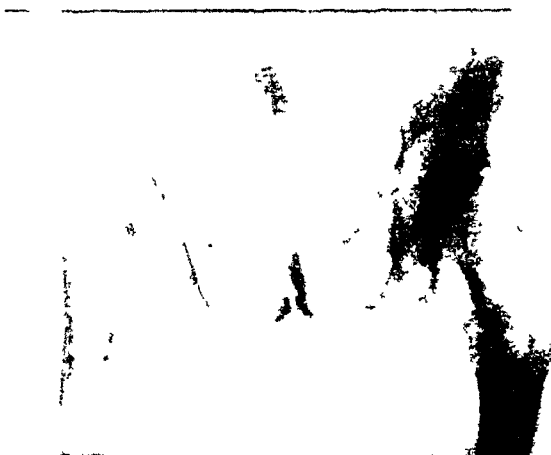


FIG. 2.

FIG. 1—(Case I.) Fifty-two years of age at time of operation. The only case with satisfactory function after Whitman reconstruction, six years after operation.

FIG. 2.—(Case II.) Sixty five years of age at time of operation. Two years after arthrodesis.

April 10, 1928.—Constant pain. Femur out of socket.

May 8, 1928.—X-ray shows osteo-arthritic changes and new bone formation. Ninety degrees motion. Rotation fair. No abduction.

November 4, 1929.—Re-admitted to hospital because of constant pain day and night. Unable to bear weight. Statement made by medical men because of bad heart: "He has three chances out of ten of surviving operation on his hip." Patient stated that he preferred to be dead rather than to continue to suffer present pain.

December 11, 1929.—Arthrodesis of hip.

March 26, 1930.—Case removed. X-ray shows union.

April 20, 1930.—Discharged from hospital.

November 2, 1931.—Gets about without use of crutches. Leads practically a normal life. No pain. Solid union in good position. Able to walk a mile. Goes about on trolley cars.

CASE III.—F. C., fifty-one years old. Fracture neck of femur, January, 1929. After admission to hospital fragments were in perfect position. Treated with Buck's extension and sand-bags. Rapid absorption of neck of femur so that at the end of three months neck had almost completely disappeared with displacement of the shaft.

March 26, 1929.—Arthrodesis of hip. November 2, 1931.—Arthrodesis solid. Does

FRACTURES OF THE NECK OF FEMUR

FIG. 3.—(Case III.) Fifty-one years of age at time of operation. On admission to the hospital.

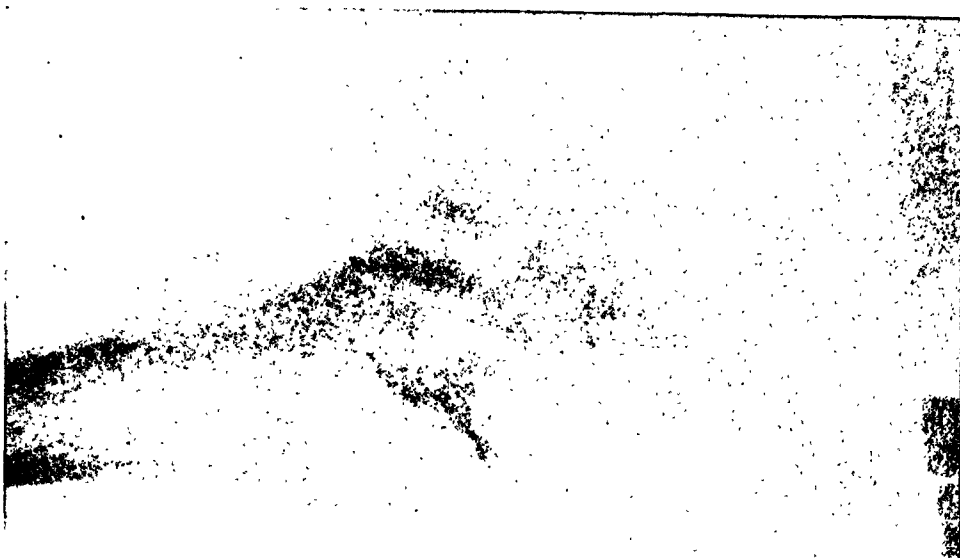
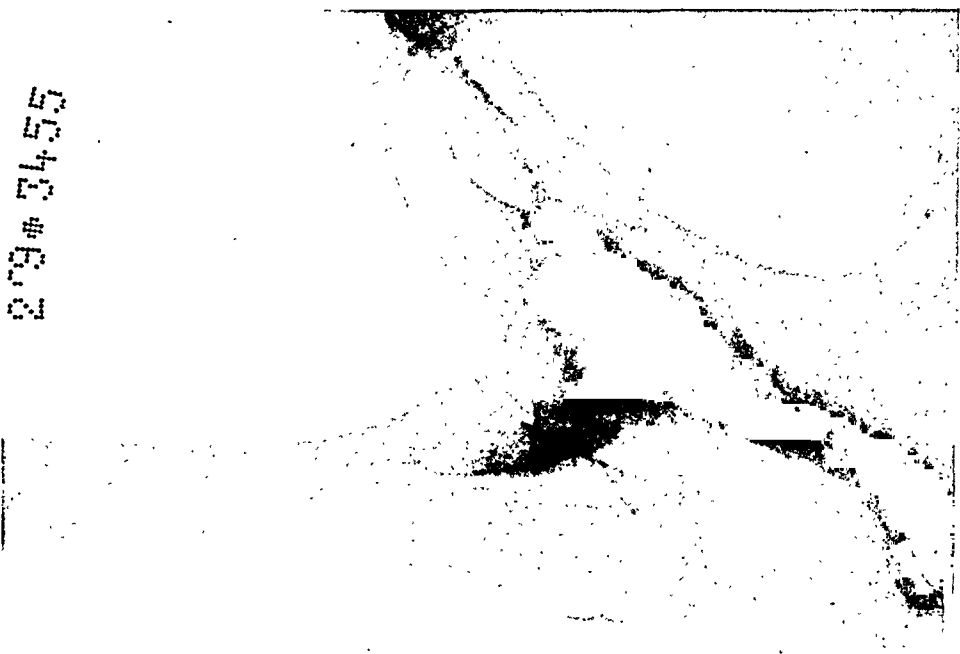


FIG. 4.—(Case III.) Three months after admission to the hospital. Complete absorption of the neck.



5543 #6.2

FIG. 5.—(Case III.) Two years and seven months after arthrodesis.



her housework. Takes care of her mother who is seventy-two years of age. Kneels and scrubs floors. Does all her own shopping. No pain except occasionally in rainy weather. This pain is felt in the adductor region.

CASE IV.—C. W., thirty-eight years old. Had fracture of neck of right femur June, 1928. Treated in hospital but fracture was not recognized, and was told that he had a sprain of his hip. Had pain and was unable to bear weight. X-ray made at the Orthopædic Hospital in September revealed ununited fracture.

October 26, 1928.—Brackett operation. Neck was largely absorbed. What was left of the base of the neck was crater-like, with portion of cortex remaining about one-half inch long. Medulla had undergone degeneration and absorption. Head of the femur was flush with the acetabulum. It bled on being denuded. Great trochanter was removed. Upper end of femur was rounded off and reduced in size. It came in firm contact with the head when the leg was abducted. Greater tuberosity was fastened to the shaft lower down. Leg dressed in abduction and slight internal rotation.

October 10, 1929.—Operation unsuccessful. Failed to get union. Fibrous union present which allowed weight-bearing fairly well but with considerable pain.

October 10, 1929.—Arthrodesis of hip. October 17, 1931.—Failure of union. Fifteen degrees motion. Leg in good position. One and one-fourth inches shortening. Has

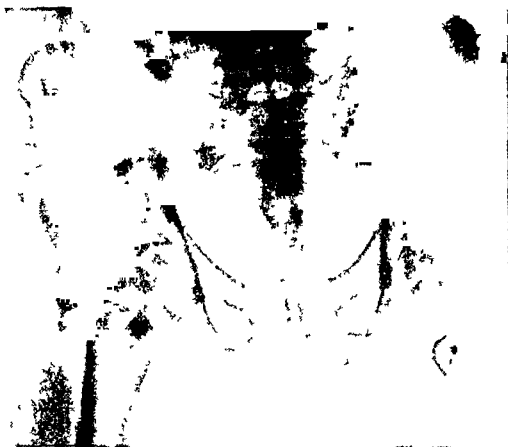


FIG. 6.

FIG. 6.—(Case IV.) Thirty-nine years of age at time of operation. Two years after arthrodesis.



FIG. 7.

FIG. 7.—(Case V.) Forty-nine years of age at time of operation. Six months after arthrodesis. Failure of fusion.

been working for one and a half years as mail-carrier, walking twelve to fourteen miles a day. On returning to work after two weeks' vacation this summer he began to have moderate pain in his hip after walking six to eight miles.

CASE V.—K. S., forty-nine years old. Fracture of neck of femur April 17, 1930. Has suffered constant pain, even at night. Unable to walk. April 23, 1931.—Arthrodesis of hip, intra- and extracapsular.

October 15, 1931.—One inch shortening. Good position. Slight abduction and slight flexion. Ten degrees motion present in flexion; no rotation; no abduction; no adduction. X-ray shows non-union.

CASE VI.—L. W., fifty-nine years old. Fracture neck of femur December, 1919. Treated in various ways, including Buck's extension. March 1, 1923.—Non-union. Complete absorption of neck. Has pain at all times. March 20, 1923.—Reconstruction operation.

September 23, 1923.—Discharged from hospital. Fair result. Has some pain on motion. October 24, 1931.—Marked disability. Can walk very little with the use of one or two crutches, or leaning on some one. She can get about in her room without a crutch by holding to different objects. Has pain. Poor result.

KNEE-JOINT ARTHROTOMY*

By JOHN J. MOORHEAD, M.D.

OF NEW YORK, N. Y.

FROM THE DEPARTMENT OF TRAUMATIC SURGERY OF THE N.Y. POST GRADUATE MEDICAL SCHOOL, COLUMBIA UNIVERSITY

IN NOVEMBER, 1925, the writer read before the New York Surgical Society, a paper entitled "Arthrotomy for Knee-Joint Calculi."¹ At that time, forty-nine cases of arthrotomy were reported, a group operated upon in the interval between February 9, 1919, and November 9, 1925. In the present essay have been collated 137 additional cases operated upon since then, making a series total of 186 up to January, 1932.

From a clinical standpoint this review assembles itself into three groups as to *causation*, namely, (1) traumatic; (2) infective or metastatic; and (3) a mixed group in which trauma and infection are inter-related. *Trauma* damages the cartilages, the fat pads, the synovia, the ligaments, and, less often, the bony elements. *Infection* damages and distorts the same structures and registers especially on the synovia and the bony elements. As to *duration*, we recognize three groups, namely, (1) acute or primary; (2) subacute or intermediate; and (3) chronic or late. As to *anatomical site*, we find the chief zone of knee-joint dysfunction to be the internal meniscus; next, hypertrophic synovitis; next, hypertrophied subpatella fat pads, and thereafter a scattering represented by exostoses (hypertrophic osteoarthritis), osteochondritis desiccans (five cases) and cysts (three cases). In practically every instance there is an association of pathological findings so that, for example, in a knee locked for eight days by a "bucket-handle" type of internal meniscus there was already a complicating hypertrophic synovitis.

In the former presentation we stressed the analogy between intra-abdominal and intra-articular knee lesions and referred to arthroliths, or "joint mice," as calculi to signify the relationship pertaining between knees and fecaliths in the appendix and calculi in the gall-bladder and urinary tract. We are impressed anew with this relationship by later experience and again state that there is such a thing as knee-joint indigestion and knee-joint colic, both of which, as in the abdomen, are curable by surgery rather than by drugs, diet, physiotherapy or apparatus.

The wide exposure of the knee-joint later to be recommended has been called by the French "laparotomy of the knee-joint," and this appellation serves to again remind us of the inherent similarity between the abdomen and the knee. There is assuredly a "surgical knee" with as great certainty as there is a "surgical abdomen," and the cure for one is genuotomy and for the other laparotomy. Further, the analogy is the more striking when we recall that today laparotomy is in every respect truly exploratory and the

* Read before the N. Y. Surgical Society, January 27, 1932.

¹ ANNALS OF SURGERY, March, 1926, LXXXIII, p. 392.

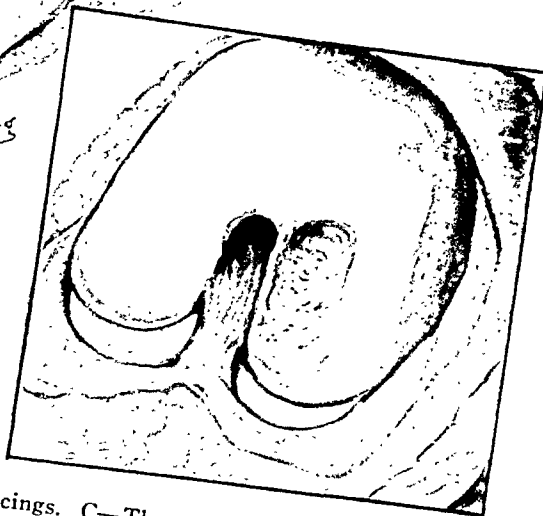
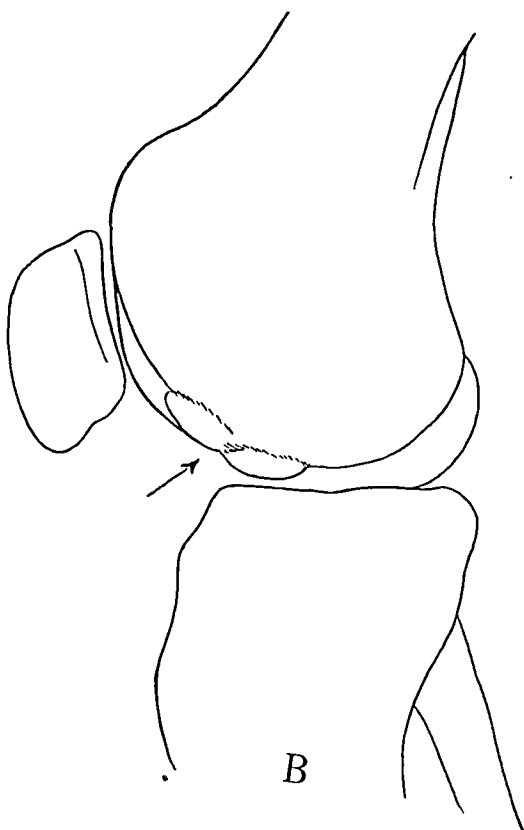
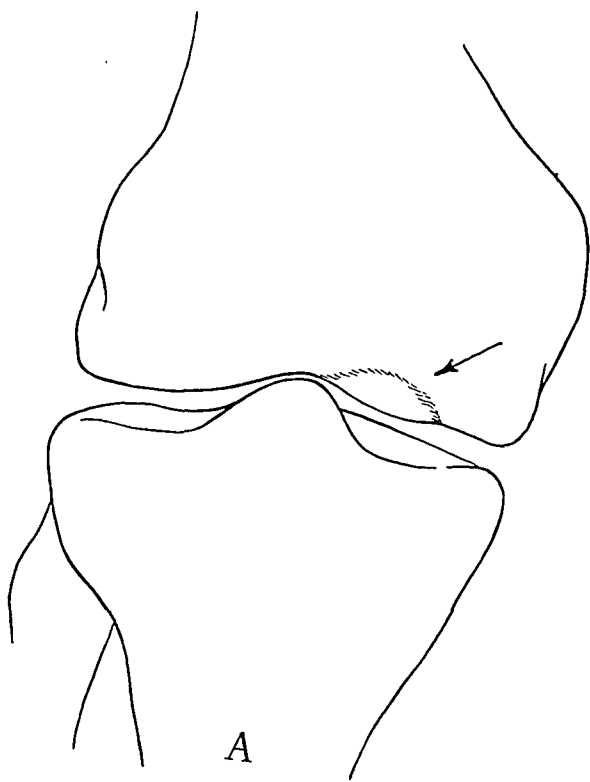
small incision is limited strictly to the acute group in which the lesion is sharply defined, as, for example, in appendicitis with classical signs and adequate findings. No longer does the small incision suffice in laparotomy for subacute or chronic cases, and the prudent surgeon explores not only the suspected region but also is alert as to the possibility of additional or complicating lesions in viscera more or less adjacent. Exactly the same experience befalls the arthrotomist, so that now the exposure is in all respects a real exploratory making every recess of the joint available.

Since October, 1923, we have abandoned every approach to the knee except the medio-lateral incision, to be described later. In the first series of cases reported we used the patella-split incision (Ollier or Jones approach) in twenty-three of the forty-nine cases, the lateral or small incision in twelve, and the medio-lateral incision in fourteen. In this additional series of 137 cases the medio-lateral incision was used 132 times.

Causation and Symptoms.—As stated, we recognize *trauma* as the determining factor in the acute and recurrent group, and here indirect violence is the usual source, although in a few of our cases direct trauma was the only element in the history. The usual story is that the knee was twisted, rotated or abducted, and thereafter pain, swelling and dysfunction appeared. This trinity of symptoms is relatively constant, and if added thereto we find local tenderness, crepitus and atrophy, the diagnosis is almost pathognomonic from the history and these six findings alone. Auscultation by the ear or stethoscope often elicits a single loud suggestive click. X-ray examination is corroborative only if calcified deposits, bone and foggy synovia become visualized. Air injections preliminary to X-ray examination we abandoned some years ago because the findings were inconstant and inconclusive. We have not used the arthroscope. Locking of the joint is a rather rare sequel in our series; but, as indicated, dysfunction is important in respect to limitation of full extension. It is a strikingly frequent complaint that dysfunction is manifest on ascending or descending stairs, and nearly all the patients volunteered the information that the joint had to be favored or guarded and was not to be relied upon for weight-bearing unless in full extension. We have been surprised at the early onset of atrophy in the acute group, and even after ten days it may be quite noticeable. We are convinced that the effusion in the traumatic group is always bloody, and that hence the term "water on the knee" is a misnomer.

We have aspirated liquid blood as late as eleven weeks after the onset of a synovitis associated with an internal derangement. In the subacute and chronic group, however, the joint effusion may resemble in color and structure normal synovial fluid.

In passing it is pertinent to say that the stability of the joint is directly related to the integrity of the quadriceps group of muscles and their associates. In point of fact, the capsule of the joint is the terminus of this muscle group and no knee-joint is stronger than the muscles controlling it. Hence the importance of muscular activation as a part of the treatment, and in



C

PLATE I.—Osteochondritis desiccans. A and B are X-ray tracings. C—The actual operative appearance.



some of our cases we have deferred operation until muscle tone was restored by special exercises.

In the subacute and chronic group, the causative factors of arthritis are often added. We are convinced that an initial trauma may provide the necessary nidus or media for the onset of arthritis, monarticular or polyarticular. We have had a number of patients with the so-called "arthritic tendency" in various joints and have seen this register on the injured knee to such an extent that virtually a monarthritis was thereby created. It is our conviction that this combination of trauma and infection often induces within the joint that form of hypertrophic synovitis which becomes a self-perpetuator or renewer of infection. Again this recalls the analogy to abdominal surgery and we are thereby reminded that the pathological gall-bladder, with or without calculi, may be a focus for arthritis. In some of our cases of hypertrophic osteoarthritis, a trauma has apparently broken off a stalactite of bone or separated a calcified tab from hypertrophied synovia and thus created an active irritant in a zone relatively quiescent even though greatly distorted, as indicated clinically and by X-ray.

We have cultured the removed fluid in a large number of cases, but even after prolonged incubation we have rarely obtained a growth of pathogenic organisms.

In our analysis of the case we regard the history as the most important clue in determining whether we are dealing with a medical knee or a surgical knee. It is not necessary to have extreme violence in order to detach a meniscus or nip or pinch a subpatella fat pad or the villi of hypertrophic synovia. This last often is thick enough and fringed enough to resemble seaweed and the analogy is the more striking if within the joint there is a high tide created by excess of fluid. Often this synovia is patchy, gray or green, almost diphtheritic in appearance.

In such cases we remove the excess of synovia, performing a total synovectomy if indicated, and we have never felt that by so doing we have robbed the joint of an essential component. We are in accord with Key and others who assert that the lining of the joint is completely restored after operative removal. Likewise we excise excess tabs of subpatella fat, especially if knobbing or excrescences obtrude into the joint. Our experience is that restitution of the joint is promoted and not impeded by that form of surgery which aims to reconstruct the joint anatomically, and hence we have often removed a damaged meniscus, performed synovectomy, and chiseled and filed off bony knobs all at the same sitting. In two such cases we have done this on both knees, the patients being so much benefited by the repair of one knee that the same relief was demanded for the other knee.

This seems to be the best answer to the query as to the possibility of a stiff knee or added disability if the intrinsic elements of the joint are removed. We are again reminded by this experience that the same fear was once aroused in respect to appendectomy, cholecystectomy, nephrectomy and splenectomy.

Treatment.—For the initial or acute attack associated with hæmorrhagic synovitis, removal of the effusion by aspiration is desirable because function is more rapidly regained, capsular distension is prevented and the formation of loose bodies from fibrinous deposits will be less frequent. To aspirate properly it is helpful to visualize the front of the joint as the face of a clock, the figure XII at the top and the figure VI at the bottom. In the left knee the aspirating needle is introduced at III and passes to XII; in the right knee the needle passes from IX to XII. It is necessary to use a large-calibred needle because the effusion is often thick. Local anæsthesia makes the procedure almost painless. After the aspiration, a snug gauze and cotton dressing is applied and the patient is encouraged to walk and to perform certain exercises to activate the quadriceps. Of these may be mentioned shrugging the knee-cap, lifting the affected limb against resistance, and pushing against the foot board of the bed. We believe, as in an initial appendicitis, that operation is not indicated if the symptoms subside after a few days. However, if there is recurrence, if dysfunction persists, if there is local tenderness, then operation offers the best chance of cure. In passing it is pertinent to stress that form of local tenderness so prominent in the meniscus group. This sign is almost as pathognomonic as is appendicitis or cholecystitis and it is elicited by point pressure with the knee bent, and it can be accentuated by rotation of the tibia.

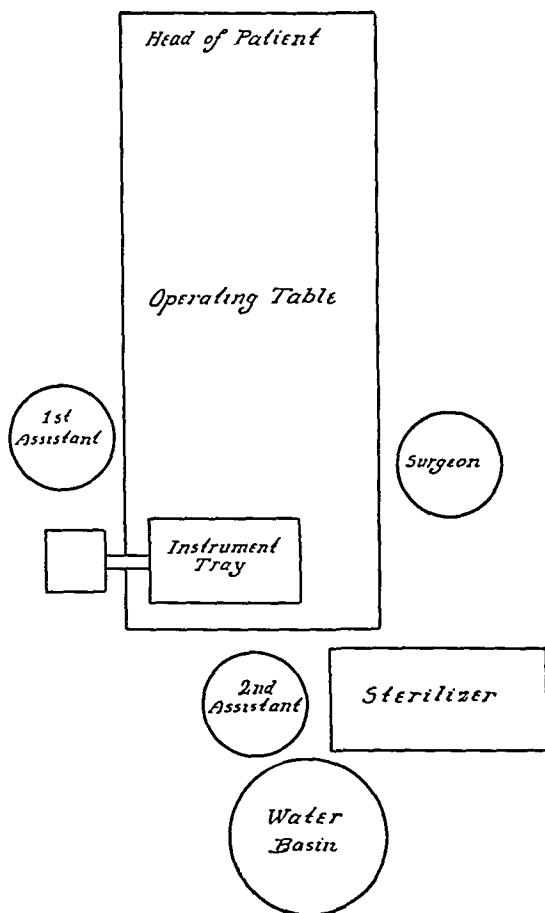


FIG. 1.—The set-up for the operating table (for the left knee).

Failure of non-operative treatment. (2) Definite evidences of cartilage injury, calculi or hypertrophic (villous) synovitis or hypertrophic osteoarthritis impairing joint function.

The Operative Approach.—As previously stated, we have abandoned the small incision directly over the meniscus even in acute cases because we have thereby missed associated pathology in two cases in which reoperation became necessary. It is surprising to find in almost every case of suspected semi-lunar injury, indisputable evidence of additional intra-articular mischief. This has created the suspicion that in some of our cases there already was distortion enough within the joint to make it the more responsive to the

Operative Indications. — (1)

accused trauma. If this is so, then it is easier to understand why in some cases very slight violence is responsible for major effects, and very great violence produces only minor effects.

Operative Details.—(1) Overnight gauze dressing of iodine saline solution (Tr. Iodine one dram, saline solution one pint). (2) Spinal or inhalation anæsthesia. (3) Tourniquet on upper thigh. (4) Rigid ultra-aseptic or Lane technic. The suture nurse sets up her table and handles all instruments and drapes with clamps. The catgut sutures are wound around a special metal frame (nicknamed by us "The Lyre") and then are easily cut in the desirable eight-inch lengths. The "Dermal" skin sutures are threaded through a drainage tube and thus do not become snarled. (5) The assistants wear two pairs of gloves during the painting and draping of the field, and discard the outer pair when the set-up is complete. (6) A sterilizer is kept boiling at the end of the table, and each instrument, after once being used, is tossed into this and taken therefrom by the second assistant using clamps, and passed into a tray of cool, sterile water, and thence the instrument is returned to the instrument tray and handed therefrom to the operator or his first assistant by a clamp. (7) Specially shaped toweling is used to protect the skin edges.

The Medio-lateral Incision.—(1) Beginning at a point three or more inches above the top of the patella, the incision is carried downward in the median line to a point a finger's breadth above the top of the patella, and then around the inner (or outer) margin of same at the same distance to the mid-line, and thence downward to just above the tubercle of the tibia. (2) The above incision is carried down to the level of the deep fascia, and, by retraction, the fibres of the vastus internus are exposed to view. (3) The incision is then deepened along the same line, separating the muscular fibres, until the capsule is reached. (4) The capsule is then incised and the joint is exposed by carrying out the deeper part of the incision along the entire route already exposed. (5) The patella and the overlying parts are now retracted, either inward or outward, and the joint is flexed by bending the knee to almost a right angle by placing the foot against the opposite thigh. This exposes every compartment except the posterior. (6) Either meniscus is now exposed to view by use of the retractors, and, if damaged, is removed, beginning at the central portion. This removal is aided by grasping the inner margin of the meniscus with an artery clamp and further flexing the knee until the posterior part of the meniscus is exposed, and then it is removed as completely as possible. It is practically impossible to remove the entire meniscus by any sort of approach, but the remaining unremoved posterior portion is so small that it does not impede subsequent joint motion. (7) The joint is now placed in the extended position and, if necessary, synovial fringes or other pathological products are removed. (8) With the aid of a Reverdin needle, plain catgut No. 2 sutures are passed through the capsule at intervals of one-half inch. A similar closure is made for the deep fascia and the edge of the muscle. A few similar sutures are used for the superficial fascia. (9) The skin closure is made with "Dermal" suture material, also passed on a Reverdin needle. (10) No ligatures are used. (11) The sutured part is now covered by several layers of gauze moistened in the "I. S." solution already mentioned. Thereafter a heavy layer of absorbent cotton is passed completely around the joint, providing the so-called "muff dressing." Two gauze bandages are then applied with the limb in complete extension, and pressure enough is made thereby to make the dressing exceedingly snug. (12) The tourniquet is then released. (Figs. 2-15.)

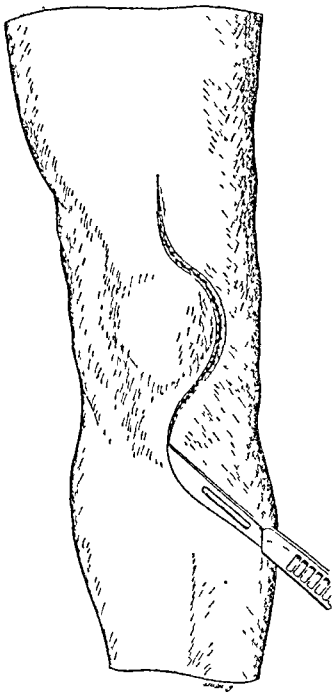


FIG. 2.

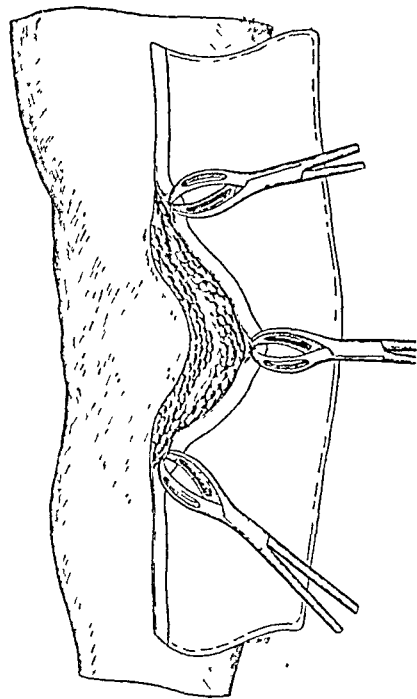


FIG. 3.

FIG. 2.—The skin incision around the margin of the patella.
FIGS. 3 and 4.—The shaped toweling attached to the skin edges.

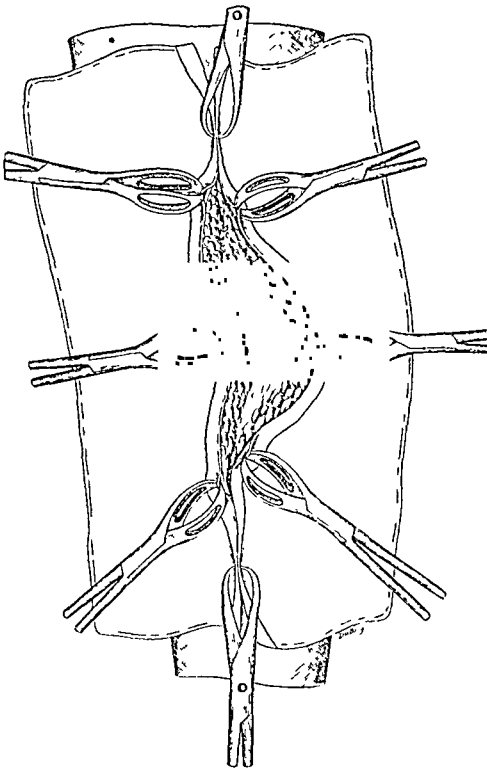


FIG. 4.

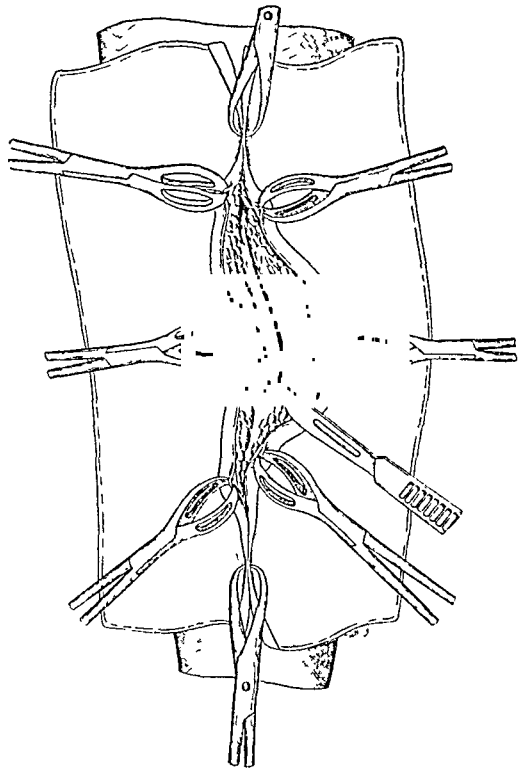


FIG. 5.

FIGS. 5 and 6.—The capsule incised.

KNEE-JOINT ARTHROTOMY

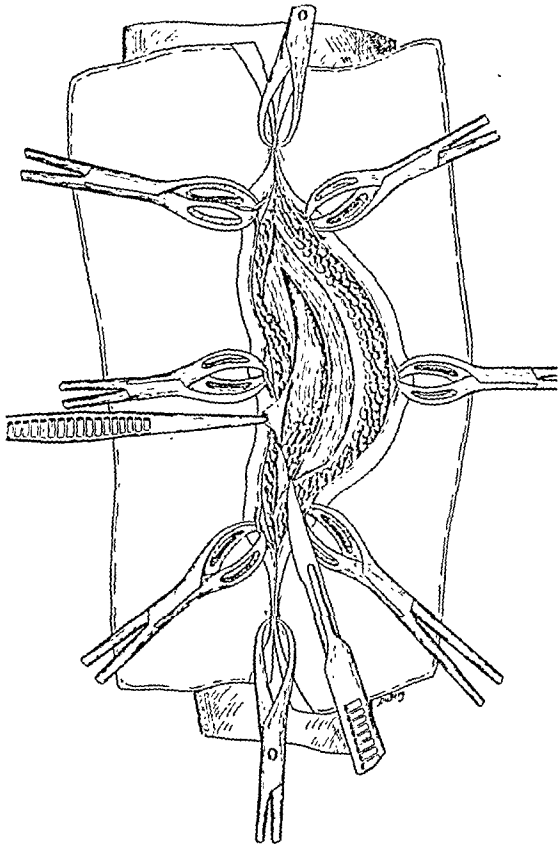


FIG. 6.

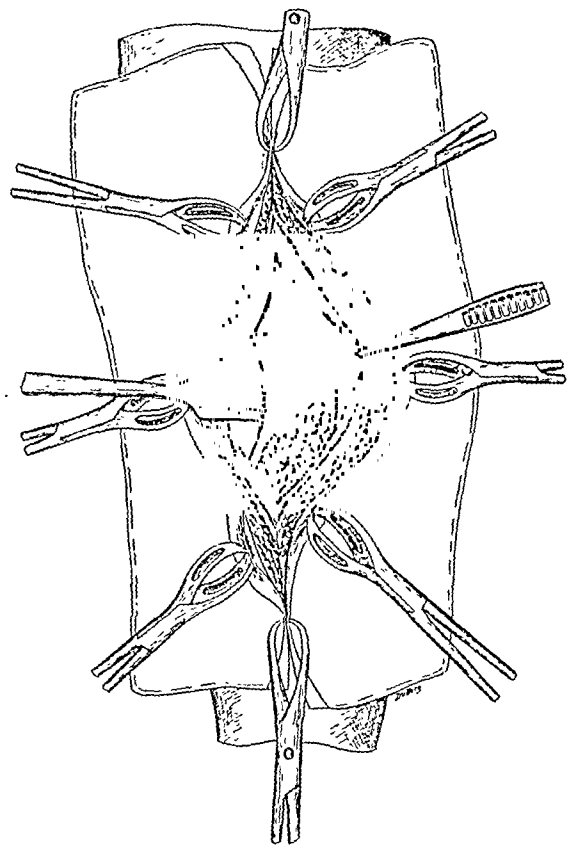


FIG. 7.

FIG. 7.—The patella retracted.

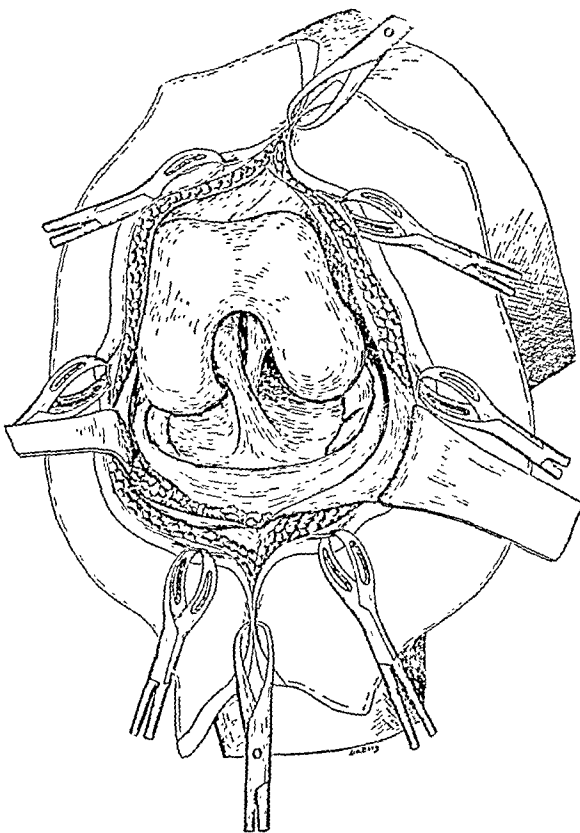


FIG. 8.

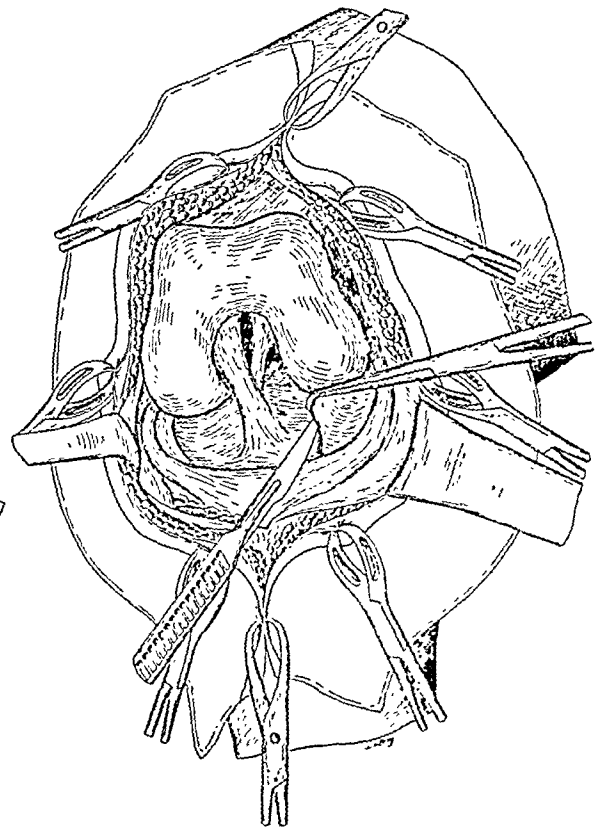


FIG. 9.

FIG. 8.—The knee flexed, showing joint contents.

FIG. 9.—Removal of internal semilunar cartilage.

The immediate post-operative care consists in leaving the limb in complete extension on two pillows until the patient recovers from the anæsthetic. Thereafter each two hours, from 8.00 A.M. to 8.00 P.M., the patient is instructed to move the joint as freely as possible. Instructions are also given to shrug the knee-cap and to make every effort to lift the extended limb off the bed. Usually on the third or fourth day the patient is urged to bend the knee over the edge of the bed, and ordinarily on the fifth or sixth day walking is permitted, at first using a chair or other form of support, but, as already stated, no crutches are allowed. The stitches are usually removed on the seventh or eighth day, and when the dressing is inspected, it is quite surprising to note the freedom from post-operative hæmorrhage, and, likewise, the absence of post-operative swelling. After the stitches are removed, a cross-strapping of adhesive plaster is usually employed.

Statistics.—Males, 129; females, 57. Oldest patient, 69 years; youngest patient 9 years. Internal semilunar injury alone, 78. Internal semilunar injury plus hypertrophic associates, 108. Lateral arthrotomy, 15; median arthrotomy, 23; medio-lateral arthrotomy, 150. Internal and external semilunar injury, 2. Osteochondritis desiccans, 5. Cysts of semilunars, 3.

End-results.—In general, the writer would state that there is no form of operative traumatic surgery in his service in which the outcome is more uniformly satisfactory, and over half the cases have been followed a year or more. There have been four cases of superficial infection in the nature of subcutaneous hæmatoma or stitch abscess. There has been no intra-articular infection, and the healing process has been exceptionally smooth throughout the series. In every case there has been maintenance of knee-joint action, and in the vast majority the range of motion has varied between 180° extension and 110° flexion. In one recent case the entire suture line broke open on the eighth day, exposing the interior of the joint in much the same way that a laparotomy incision will occasionally tear asunder. This case—the most marked manifestation of hypertrophic synovitis in the series—was that of a sixty-year-old police sergeant, and after resuture primary union was obtained with a range of motion of from 180° to 100°. Many of the patients have been athletes, and numbers of them have been able to continue such sports as football, tennis and hockey after the operation without any apparent discomfort or embarrassment. This is particularly true in the group in which there was early restoration of quadriceps activity, a feature which has been stressed above. There was one death already reported in the first series as due to embolism.

The average period before resuming light work is eight weeks from the date of operation, but in many coöperative patients this period can be much shortened.

CONCLUSIONS.—The features already stressed in 1925 as to knee-joint arthrotomy are again emphasized, namely:

(1) The surgical knee is a type of monarthrititis initiated by trauma, but often activated or aggravated by distant infection.

(2) The internal meniscus is more often involved than any of the other

KNEE-JOINT ARTHROTOMY

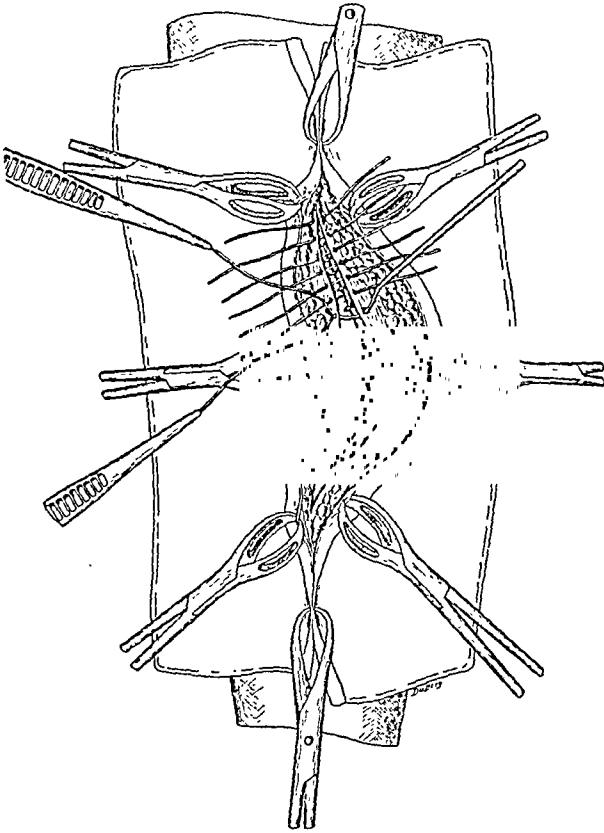


FIG. 10.

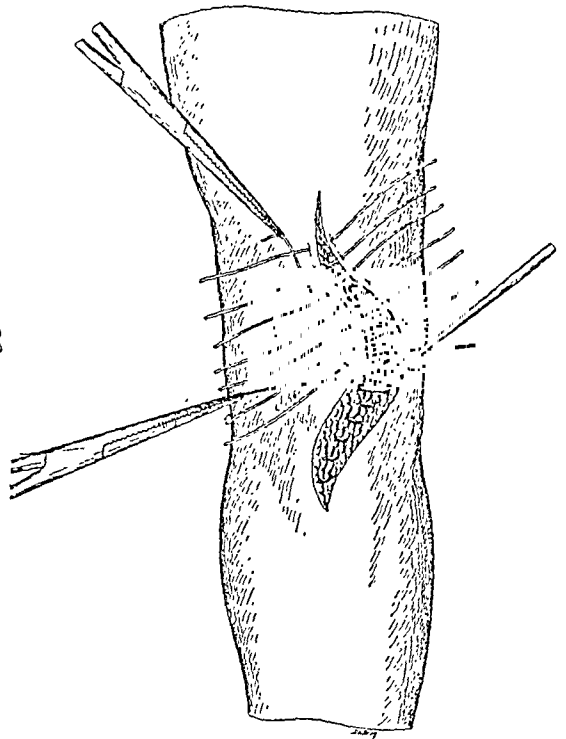


FIG. 11.

FIG. 10.—Closure of capsule and muscle-fascia layers by interrupted catgut sutures.

FIG. 11.—Skin closure by interrupted sutures of dermal material.

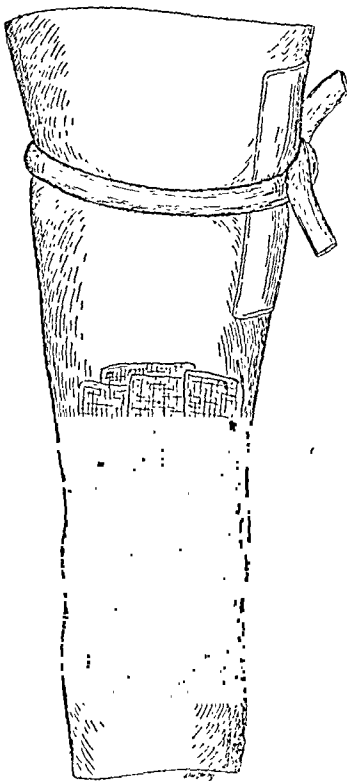


FIG. 12.

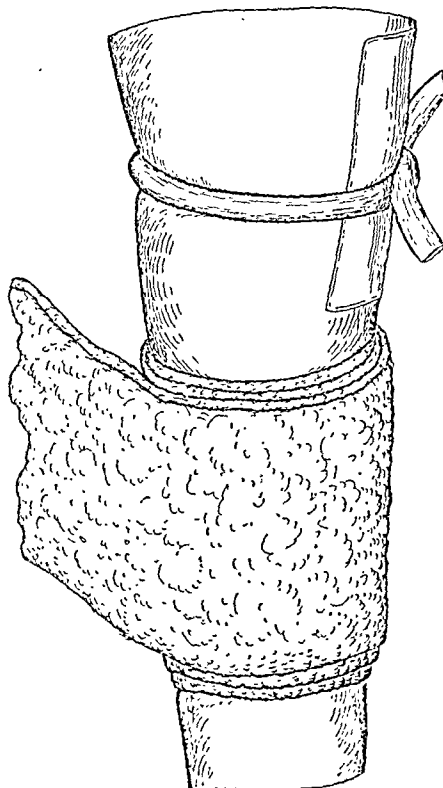


FIG. 13.

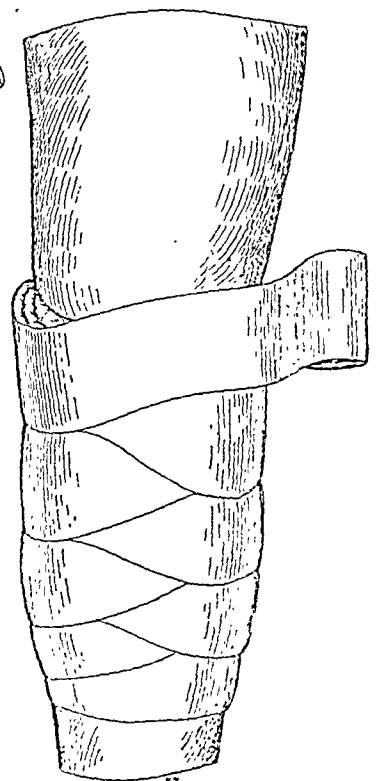


FIG. 14.

FIGS. 12 and 13.—Gauze and heavy cotton "muff" dressing.

FIG. 14.—Bandage and removal of tourniquet.

structures; the next commonest findings are hypertrophied fat pads, villous excrescences, and bone fragments.

(3) The cardinal signs are pain, synovitis, and joint limitation; to these are often added atrophy, joint instability, and crepitus.

(4) X-ray examination is of positive value only when the arthroliths are calcified.

(5) The history and examination usually present a fairly typical picture so that patients fall into three groups (acute, subacute, and chronic) as to age in years and age in pathology.

(6) Arthrotomy, limited or general, is notably effective in a selected group of patients.

(7) After-treatment by active mobilization is an important feature.

(8) The ultra-aseptic (Lane) technic has given primary union in this series of 186 cases with the exception of four with superficial infection.

(9) Arthrotomy does not contraindicate future joint activity, even in athletes, if the articulation has not been too greatly damaged prior to operation.

(10) Accumulating experience indicates that general arthrotomy is a wiser procedure than limited arthrotomy, and, hence, this latter type of approach should be reserved for early cases, or those in which the diagnosis is relatively certain.

(11) The length of the incision is no bar to free active mobilization, and with any form of approach the patient can, with safety and profit, be encouraged to walk within the first week.

(12) The analogy between intra-abdominal lesions and intra-articular knee lesions is very striking as to symptoms and treatment.

(13) Recurrent synovitis is usually more due to intrinsic than extrinsic causes, and relief therefrom is more certain by surgery than by physiotherapy, apparatus or drugs.

(14) This series of 186 cases has emphasized the importance of surgical attack early rather than late, and the prophecy is made that, with accumulating experience, exploratory arthrotomy will acquire the same vogue as exploratory laparotomy.

(15) Except as to minor details, there has been no change in the operative technic described six years ago.

(16) The diagnosis is usually made by the history, and in the vast majority of cases the X-ray and the arthroscope are not necessary aids.

(17) We remain partisan to the use of the tourniquet, ultra-aseptic hands-off technic, early mobilization, and stress the necessity for overcoming atrophy of the quadriceps.

AN OPERATION FOR RECURRENT INFERIOR RADIOULNAR DISLOCATION*

BY ELDRIDGE L. ELIASON, M.D.

OF PHILADELPHIA, PA.

DISLOCATION, complete or incomplete, of the lower extremity of the ulna is by no means a rare or unusual condition. While it may occur as a result of joint destruction secondary to arthritis, bone disease and suppurative conditions of the hand and wrist, it most often is secondary to trauma. As a rule, the causative trauma is that incident to a fall on the heel of the hand, with the resultant bone injury commonly spoken of as Colles' fracture. In addition, however, to the fracture of the radius, further soft-tissue injury occurs, incident to the continued force transmitted through the hand.

When the radius breaks, the lower fragment is driven backward and upward. The lower end of the ulna not articulating against the carpus is not affected by the end on force, but is affected by the secondary supination and lateral strain incident to the upward and rotating dislocation of the carpus attached to the lower radial fragment. To permit this displacement from the ulna, either the ulna styloid must fracture near its base, carrying with it the ulna attachment of the intrinsic triangular ligament, the whole then displacing with the carpus, and hand, or the styloid holds fast and the triangular ligament ruptures at its radial attachment and secondarily the extrinsic or anterior and posterior inferior radioulnar ligaments suffer injury. By far the greater proportion of the subsequent disability in these fracture cases is due to the incident derangement of the joint relationship rather than to any bone deformity *per se*. Although the above combination of injuries is the usual condition of affairs, luxation of this joint does occur without bone injury. This may be a result of chronic oft-repeated trauma, causing the so-called luxation described by Gayraud (quoted by Milch) or the condition referred to as Madelung's deformity.

In young people, with more or less elastic bones, acute trauma may result not in fracture but in a tearing of the above-mentioned ligaments with a consequent luxation, usually anterior, of the lower end of the ulna. Although the literature is replete with considerations of dislocations associated with disease or fracture, there are comparatively few—approximately fifty cases reported—of uncomplicated anterior dislocation.

Cotton and Brickley, in 1912, reviewed the literature and found that the first case reported was a post-mortem, one by Desault. The next reference was forty years later, by Dupuytren. From that date until 1907 twenty-six references are reported. The reader is referred to the above excellent article

* Read before the Conjoined Meeting of the New York Surgical Society and the Philadelphia Academy of Surgery, February 10, 1932.

for the bibliography up to this time. Since then some twenty more cases have been reported. Milch, in 1925, gave an admirable presentation of the subject to date, together with a description of a very ingenious and cleverly conceived operation for a correction of the condition. It cannot be determined, however, that he ever employed the procedure on a living patient. Painstaking examination of the data at hand discloses the fact that many surgeons have attempted various methods to correct this troublesome condition. Von Mayer advocated the use of an external band, Hoffa employed wires between the bones, Darrach resected the lower end of the ulna, while other text-book authorities advised an osteotomy of the radius in an attempt to tighten the relaxed ligaments. Behrend reports a case in which he obtained a good result following nailing of the two bones together. Mitchell reports a bone graft used in one case associated with a fracture of the ulna styloid. Wilson and Cochrane employed a fascial graft to repair the triangular cartilage. Bognar, in 1930, reports two cases in young adults in which he used a fascial sling passed around both bones as a cuff. One would gather from the article that this was patterned after Milch's fascial cuff, except no mention is made of threading the radius. In one of the patients, Bognar used a fascial graft from the styloid of the ulna to "the adjacent metacarpal bone." The first case had a good result for two years; then, incident to a fracture, the dislocation recurred. The second case was only four weeks old at time of report.

It will be noted from the above that there are various treatments reported, in some instances with successful results; in others the results are not mentioned. Most of the methods available for reporting were such as to preclude any possibility of a complete return of the function of forearm rotation, together with anatomical perfection, witness the nail, the wire, the bone graft, excision of the ulna, *etc.* However, two writers, Wilson and Cochrane, and Bognar, report fascial employment successfully used in patients, while Milch suggests, as stated, a fascial sling. This author uses a fascia slip eight inches long and one inch wide, and by means of four incisions and drill holes on the anterior and posterior aspect of the radius, throws the cuff sling around the two bones.*

Influenced to a great extent by this latter article, the present writer, after a study of the three ligaments concerned, was convinced that the simple cuff of fascia was not sufficient, with the drill holes so far afield in the radius as described by Milch. The sling, to be sufficient, should simulate as near as possible the attachment and action of the triangular ligament. If, therefore, the sling would permit the ulna to rotate within it as the head of the radius

* Dr. C. L. Lowman informs me just recently that he used a fascial sling with good results in a case of Madelung's disease. Dr. Kellogg Speed reports to me that he has recently used the same type fascial sling with good results in a dislocation incident to a Colles' fracture. Doctor Milch, whose article is referred to above, writes that although he himself has never done this operation on a patient, nevertheless his ideas have been carried out by Continental surgeons several times with success.

RECURRENT INFERIOR RADIOULNAR DISLOCATION

rotates within its ligament, and if it could be attached to the radius approximately at the site of the triangular ligament attachment, a nearer approach to the ideal would be obtained. Furthermore, appreciating the fact that extreme supination has been shown not only to tear the anterior radioulnar ligament but also to tear the triangular ligament away (Fig. 1) from the radius, one would naturally be influenced to attach any new support as far posterior as possible to the plane of the radioulnar joint in order to counteract this forward tendency. Hence, the posterior position of the drill hole in the mesial aspect of the radius as shown in Fig. 2. Furthermore, it is readily seen that a sling of this sort will merely maintain approximation; hypersupination must be combated by repair of the extrinsic ligaments in addition. Fig. 3 will illustrate these points better than text can describe them.

With the above experiences of others in mind as well as appreciating the points in surgical anatomy as outlined above, the following case is here reported. It is of interest to note that this patient is a young nurse and that the condition is reported several times as occurring in hospital nurses. In two instances the injury occurred by forcible supination while in the act of restraining a patient.

CASE REPORT.—G. N., a nurse, aged nineteen years, was admitted to Service C, University of Pennsylvania Hospital, May 25, 1929, with the complaint of weakness and some dull pain in the left wrist. She gave the history that while cleaning a bathtub six months previously she slipped and fell on her outstretched hand. She consulted a physician at once and his clinical and X-ray examination disclosed no fracture. Since that time, although not completely disabled, the patient states that the wrist has become progressively weaker, less to be depended upon and somewhat more uncomfortable as a result of a dull ache.

Physical examination revealed little of importance as far as the present complaint is concerned except that on supination of the left forearm the lower extremity of the ulna dislocated forward completely at the inferior radioulnar articulation. At the same time, it was noted that pressure with the examining fingers between the two bones disclosed an abnormal laxity of the common attachments, permitting an unusual lateral separation of the bones at this joint. The diagnosis, confirmed by X-ray, was that of a recurring dislocation at the inferior radioulnar articulation. For relief the following operation was done:

An incision was made over lower end of the left radius, and the bone exposed by retraction of muscles. The radial nerve was identified. Incision was then made on the opposite side of the forearm over a corresponding part of the ulna, which was also exposed. With the aid of blunt dissection, an aneurism needle was carried around the

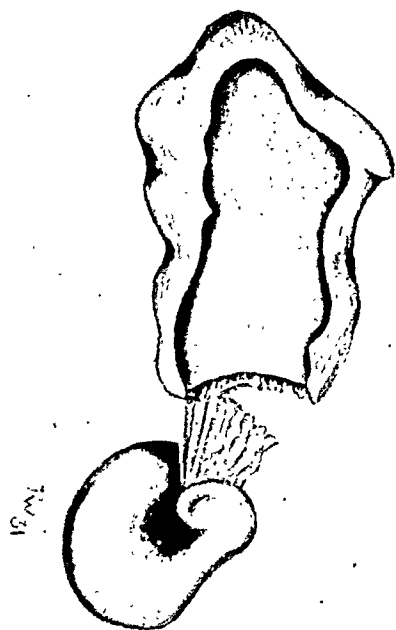


FIG. 1.—Illustrates diagrammatically the torn triangular ligament with the resultant separation of the two bones.

ulna, perforating the pronator quadratus muscle. In this manner, two loops of heavy silk were passed around the bone. The ulna was now dislocated forward and the radius was then drilled in an oblique direction from its posterior and ulnar aspect forward and outward to penetrate the outer radial cortex about one and one-half inches above the styloid process. The drill used was slotted so that a loop of silk could be passed through the drill hole as the drill was removed. At the same time a probe was passed along the drill.

An incision was made in the outer aspect of the left thigh, exposing the fascia

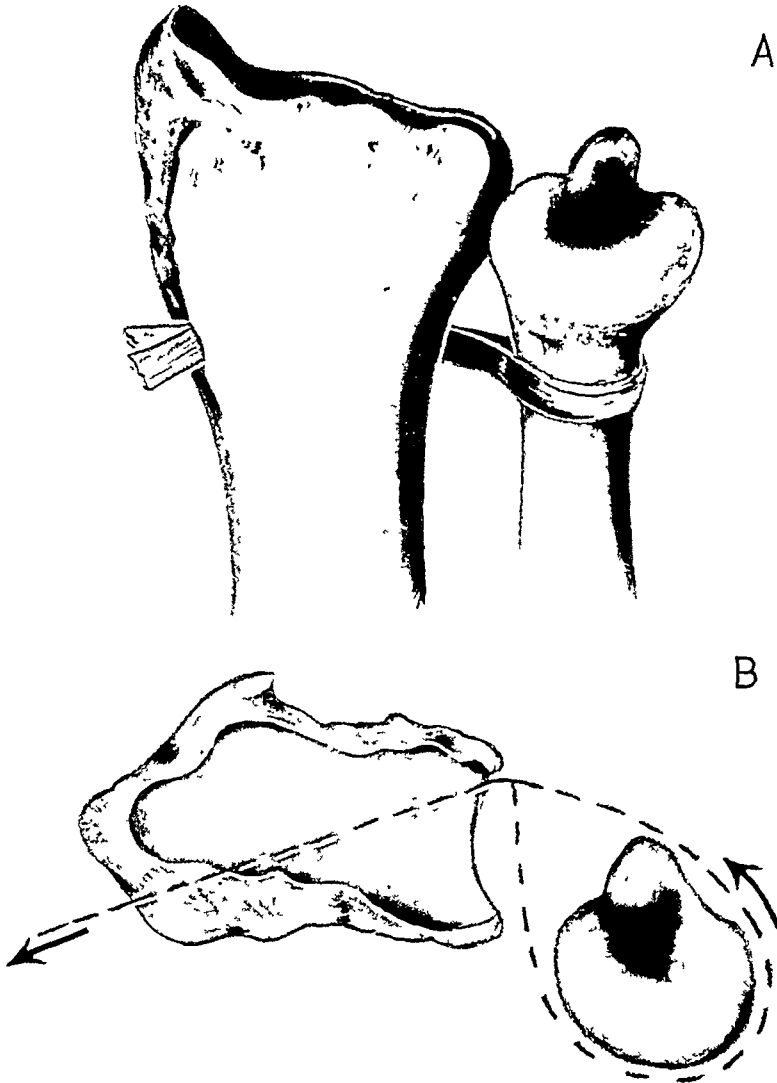


FIG 2—(A)—Illustrates the position of the fascial sling (B)—The dotted line shows the direction taken by the drill hole, the arrow indicating the direction of the pull when the sling is tightened.

lata, a strip of which, eight inches long by one-half inch wide, was removed. The defect in the aponeurosis was sutured by both continuous and interrupted sutures of iodine gut, and the skin closed with interrupted silk sutures and clips. Using the silk loops, the fascial strip was drawn about the ulna so as to encircle it and serve as a sling. The two ends of the fascial sling were drawn through the drill hole in the radius separately, one being threaded through the probe; the other placed in the loop of silk. When the two ends of fascia were drawn taut at this stage of the operation, the ulna was held in

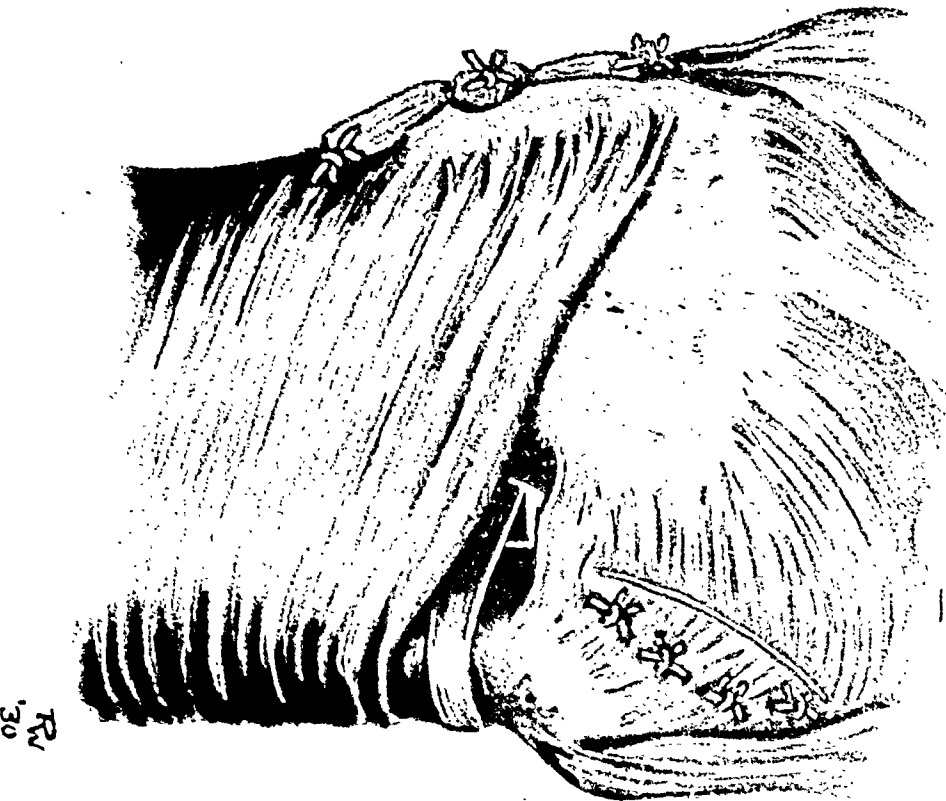


FIG. 3.—Illustrates the fixation of the fascial sling ends on the radius and also the plication of the anterior ulnar ligament.

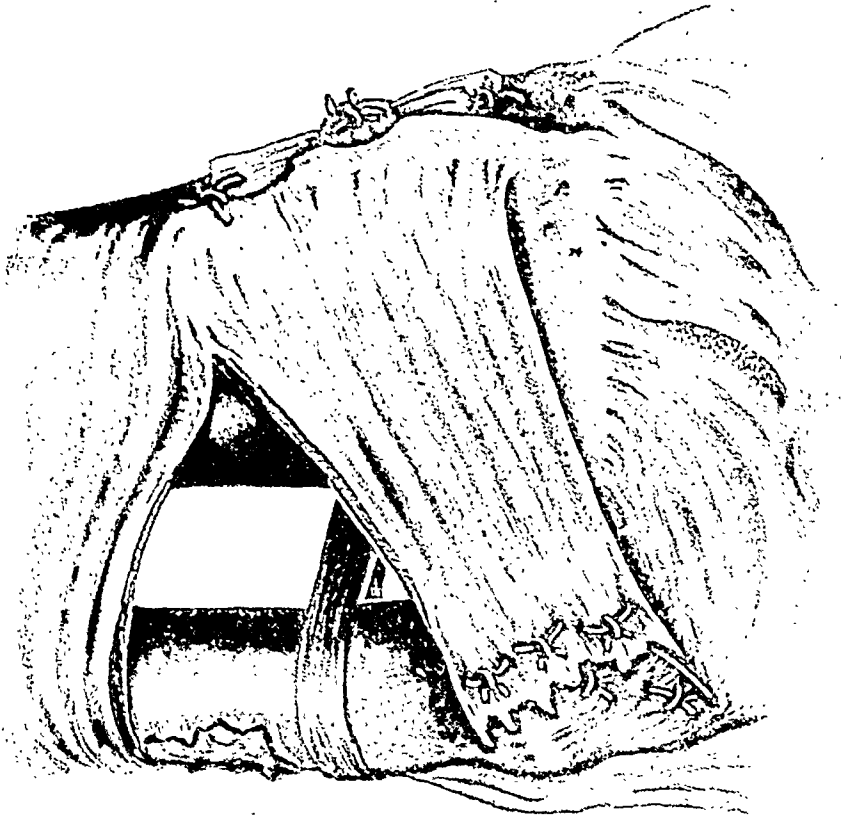


FIG. 4.—Illustrates the transfer of the distal portion of the pronator quadratus muscle.

position and did not dislocate. The free ends were passed around the tendon of the supinator longus very close to its insertion. The two ends were then tied together and a suture placed through the two ends of the knot and through the tendon to prevent slipping. The sling suspension of the ulna was tested at this point and found to operate satisfactorily. The skin was closed with a continuous silk suture and the arm was dressed upon an internal right-angle splint.

The patient had an uneventful recovery and when examined for the follow-up record six months later had a perfect functional and anatomical result. A short while after this report the patient stated that while restraining a post-operative case recovering from a general anæsthetic, her wrist was acutely and forcibly supinated with resultant pain and disability. Examination revealed a subluxation forward of the lower end of the ulna although the laxity and the laterally increased motion which was evident between the bones, the result of the first injury, was not evident at this time. In other words, the two bones were held snugly together, laterally, but the ulna on supination slipped into a partial forward luxation.

Impressed by studies of dissected anatomical specimens as well as by the statements of anatomists that although the triangular ligament maintains the normal lateral approximation of the two bones, the anterior and posterior, radioulnar ligaments are chiefly concerned in preventing excessive, backward or forward displacement of the lower end of the ulna during pronation and supination, it was felt that the first operation only partially corrected the trouble, by the sling substitution for the triangular ligament. A second operation, therefore, to shorten the extrinsic ligaments was advised and undertaken December 6, 1929. The previous incision over the ulna was reopened, the scar being excised. The ulnar vessels and nerve were located and displaced toward the radial side. The external joint structures were cleared as well as the site of the previously placed sling of fascia lata. The latter was found intact, snugly fitting around the shaft of the ulna, about which it slid smoothly, during rotation of the forearm. Macroscopically, its appearance differed in no wise from normal living fascia lata. The subluxation appeared to be permitted by reason of a greatly stretched, anterior, radioulnar ligament. An incision was made through the anterior ligament into the joint. The slack of this ligament was then taken up by overlapping or plicating with interrupted chromic catgut sutures. (See Fig. 3.) A similar procedure was carried out on the posterior ligament. To further the approximation factors between the two bones a portion of the ulnar attachment of the pronator quadratus muscle was shifted distally and sutured over the joint as an additional splint. (Fig. 4.)

Following this second operation, a wristlet was worn for six months and the patient warned against extreme or forcible supination. When last examined, a year and a half later, the patient reported an excellent result, with freedom from discomfort and weakness. Physical examination revealed some slight anterior excursion on extreme supination.

Comment.—An operation has been described for anterior recurrent dislocation of the lower end of the ulna uncomplicated by bony deformity due to fracture or disease. In the reported case, this operation was performed in two stages. The second stage was made necessary because the true condition of affairs was not entirely appreciated at the first operation. Should a second case of this type come to hand, the entire procedure might best be accomplished with one operation.

The procedure is a very simple one. The approach incisions are safely removed from all important structures and no tendons or nerves need ever be jeopardized. The construction appears to be on a sound anatomical and functional basis.

BIBLIOGRAPHY

- Internal Fixation of Fractures and Dislocations with Human Fascial Suture. *ANNALS OF SURGERY*, vol. lxxxviii, p. 879, November, 1928.
- Behrend, M.: Habitual Dislocation of the Ulna. *Penna. Med. Jour.*, vol. xx, p. 533, May, 1917.
- Carter, R. M.: A Note on Two Unusual Dislocations. *Wisconsin Med. Jour.*, vol. xxiii, p. 196, September, 1924.
- Corrigan, S. H.: Compound Dislocation of the Lower End of the Ulna. *Canada Med. Assn. Jour.*, vol. xvi, pp. 689-690, June, 1926.
- Cotton, F. J.: Dislocations and Fractures. W. B. Saunders Co., 1925.
- Cotton, and Brickley: Luxation of the Ulna Forward at the Wrist, without Fracture. *ANNALS OF SURGERY*, vol. lv, p. 368, 1912.
- Cotton, and Brickley: Luxation of the Ulna (Forward) without Fracture. *ANNALS OF SURGERY*, vol. lv, p. 368, 1912.
- Darrach, W.: Habitual Forward Dislocation of the Head of the Ulna. *ANNALS OF SURGERY*, vol. lvii, p. 928, 1913.
- Darrach: Anterior Dislocation of the Head of the Ulna. *ANNALS OF SURGERY*, vol. lvi, p. 802, 1912.
- Gibson, Alex.: Uncomplicated Dislocation of the Inferior Radioulnar Joint. *Jour. of Bone and Joint Surg.*, vol. vii, p. 180, January, 1925.
- Goyrand: Bulletin de la Société de Chirurgie de Paris, p. 596, 1861. Quoted by Milch.
- Graham's Surgical Diagnosis. Section on Dislocations, vol. i, p. 696.
- Grieg, D. M.: Congenital Dislocation of the Ulna. *Edinburgh Med. Jour.*, vol. xxxi, p. 373, July, 1924.
- Halzberg, H. L.: Bilateral Congenital Backward Dislocation of the Lower End of the Ulna. *Jour. Am. Med. Assn.*, vol. lxxvii, p. 2056, December 24, 1921.
- Hetilap, Orvosi: Habitual Dislocation of Lower Ulna. vol. lxxv, pp. 291-292, March 29, 1930.
- Hitzrot, J. M.: Anterior Dislocation of the Lower End of the Ulna—Late Result. *ANNALS OF SURGERY*, vol. lv, p. 623, 1912.
- Hoffa: Verhandlungen der Deutschen Gesellschaft für Chirurgie, 27th Kongres, 1898. Heft 1, p. 156. Quoted by Milch.
- Horan, W. A.: Uncomplicated Forward Luxation of the Ulna. *Jour. Am. Med. Assn.*, vol. xc, p. 1710, May, 1928.
- Masmontiel, F.: Congenital Dislocation of the Wrist. *Lyon Chir. Lyons Abst., Jour. Am. Med. Assn.*, vol. lxxvii, p. 652, August 20, 1921.
- McClure, E. C.: Madelung's Disease. *Journal of the Iowa State Med. Soc.*, vol. vi, p. 152, April, 1916.
- Milch, H.: Dislocation of the Inferior End of the Ulna. Suggestion for a New Operative Procedure. *Amer. Jour. Surg.*, September, 1926.
- Milch, H.: Use of Loop of Fascia in Treatment of Lower Ulna and Upper Radius. *Arch. klin. Chir.*, vol. cli, pp. 176-183, 1928.
- Mitchell, A. P.: Recurrent Anterior Dislocation of the Lower End of the Ulna Complicated by an Ununited Fracture of the Styloid Process of the Ulna. *British Jour. of Surg.*, vol. ix, p. 555, 1922.
- Neuberger: Dislocation of the Lower Radioulnar Articulation. Review of Thirty-four Cases. *Deutsch. Ztschr. f. Chir.*, Leipzig, Abst. in *Jour. Am. Med. Assn.*, p. 829, September 3, 1921.
- Speed, Kellogg: Common Dislocations. *Amer. Jour. of Surg.*, vol. vi, p. 517, April, 1929.
- Speed, Kellogg: Fractures and Dislocations. Lea and Febiger, 1928.
- Stimson: Fractures and Dislocations. (Section on Ulna), p. 667.
- Von Mayer: Quoted by Hoffa, *loc. cit.*

- Wilson, and Cochrane: Fractures and Dislocations. J. B. Lippincott Co., p. 267; *Ibid.*, p. 295, 1925.
- Wilson, *et al.*: Thirty-second Report of the Progress of Orthopedic Surgery. Arch. of Surg., vol. xiv, p. 1271, 1927.
- Yoder, A. B.: Unique Wrist Injury. Jour. Am. Med. Assn., vol. lxi, p. 767, September 6, 1931. (Recurrent Anterior Dislocation of the Ulna.)

DISCUSSION—DR. WILLIAM DARRACH (New York) agreed with Doctor Eliason that it is an unusual condition very rarely occurring by itself. The development of such a condition with Colles' fracture is very common. A fairly high percentage of Colles' fractures complain of pain on supination and pronation, which may last for many years. Mechanics suffering from this condition have sharp jabbing pain, sometimes causing them to drop their tools into the machinery. Women patients complain of pain on wringing clothes. At the suggestion of Dr. Kirby Dwight, a method of treating this condition was tried which seems to put an end to the symptoms, namely, removal of the lower end of the ulna. The speaker has performed this operation now in over sixty cases and most of them have given a satisfactory result. Doctor Murray has also done these cases. The lesion is not only that the lower end of the ulna tends to rotate forward or back because the fibrocartilage is ruptured or the anteroposterior ligaments ruptured, but because of the relative shortening of the radius. Anything that shortens the radius will give derangement of the lower radioulnar joint. In some very bad Colles' fractures with the lower end of the ulna entirely out of contact with the radius, there may be almost no symptoms at all on pronation and supination. If the bone is not in contact one gets no symptoms. It is only in the milder cases of shortening of the radius that the severe symptoms follow. His procedure is to go in from the outer side, split the periosteum, bite the bone across, remove the lower portion of the ulna leaving the styloid process, and close the periosteum. Wait three days and then mobilize. The periosteum is left so that the styloid maintains its connection with the remaining portion of the ulna. There is rapid return of function. An experience of over twenty years convinces him it is a sound procedure, removes the pain, removes the deformity, and does not interfere with the strength or usefulness of the wrist.

DOCTOR DWIGHT (New York) said that he has used the operation Doctor Darrach described a number of times after he did the first one and found that it relieved the patient of such symptoms as pain on extreme pronation and supination, and of deformity. Doctor Eliason's procedure is perhaps a better operation in those cases in which the dislocation of the inferior radioulnar joint is not accompanied by a shortening of the radius. With fractures of both bones of the forearm we always try to get end-to-end reduction of the shaft of the radius, even if we can not do the same for the ulna. Apparently there are no such symptoms from relative shortening of the ulna as from shortening of the radius.

DR. A. BRUCE GILL (Philadelphia) remarked that the case presented by Doctor Eliason illustrated one type of inferior radioulnar dislocation. It is

due to traumatism and is not associated with any defect of the bones. Another type is that which is due to or associated with shortening of the radius. This shortening may be a result of a fracture as mentioned by Doctor Darrach or may be due to defective development of the lower epiphysis of the radius caused by osteomyelitis which has interfered with its growth. The ulna outstrips the radius in its growth and its lower end is pushed downward and backward. Congenital defects of the radius also produce the same result. In Madelung's deformity there is relaxation of the radioulnar joint, posterior subluxation of the ulna, and frequently curving of the radius. This deformity of the radius produces a relative shortening. The cause of Madelung's deformity is not definitely known but occurs most frequently in individuals such as washerwomen, who do hard work with their hands, particularly with movements of rotation.

When this condition is due to a shortening of the radius the proper method of treatment is to shorten the ulna so that the two bones are made of normal relative length. The procedure which he employs for this is to make a linear incision through the periosteum of the ulna just above its lower extremity and to resect subperiosteally sufficient of the shaft to compensate for the shortening of the radius. The lower fragment of the ulna is brought into apposition with the upper fragment and the periosteum is sutured again over the point of fracture.

Doctor Eliason's operation is a rational one and it has given a very good result in this case. The object, of course, is to reinforce and strengthen the normal ligaments of the joint without producing limitation of normal motion. The problem here is the same which is met with in the sternoclavicular joint, the acromio-clavicular joint and the knee-joint. The use of a fascia lata suture of ligaments is probably the best means of accomplishing the desired end in all of these cases.

A STUDY OF THE CAUSE OF DEATH FOLLOWING BURNS

By W. GROCE HARRISON, JR., M.D., AND ALFRED BLALOCK, M.D.

OF NASHVILLE, TENNESSEE

FROM THE DEPARTMENT OF SURGERY OF VANDERBILT UNIVERSITY

THAT the primary cause of death in superficial burns is due to a circulating toxin liberated in the tissue at the site of the burn has long been held by numerous observers. Others, however, believe that the rôle played by a circulating toxin is a minor one.

Avdakoff,¹ in 1876, found that blood from a burned animal often caused the death of the second animal. He was among the first to suspect that a specific toxin entered the circulation after the burn. Kizanitzin² extracted a toxin from the blood, urine, and tissues of a burned animal and obtained no such substances from a normal animal. Pfeiffer³ isolated cleavage products of protein decomposition from burned skin. Vogt,⁴ working on rats and guinea-pigs, found after cross-circulation had been established between two animals that, if one were burned, both animals frequently showed hyperæmia of the abdominal organs and in many instances both died. Weiskotten⁵ observed the degenerative changes in the adrenals, and Bardeen⁶ described the alterations in the lymph-glands found at autopsy and both felt that a circulating toxin most likely caused these changes.

The chief proponents of the toxin theory in recent years have been Robertson and Boyd.⁷ They believed that a toxin consisting of primary and secondary proteoses is produced in the burned tissue of rabbits and that this toxin circulates in the blood. Whole blood was found to be quite toxic while blood serum exerted very little toxic effect. Underhill⁸ ascribed many of the deleterious effects following burns to the marked increase in the concentration of the blood. Blalock⁹ determined the amount of fluid that was lost in the subcutaneous tissues of dogs after burns. This fluid was found by Beard and Blalock¹⁰ to have almost exactly the same protein content as blood plasma and they believed the loss of blood plasma into the burned area to be the principal if not the sole cause for the shock that develops within forty-eight hours following burns.

The object of the experiments here reported was to determine whether or not the cause of death following superficial burns is due primarily to toxins circulating in the blood-stream.

METHODS AND RESULTS

Profoundly anæsthetized dogs were used in all instances. They gave no evidence of pain during the course of the experiments. Three different groups of experiments were performed.

GROUP I.—*The Effects on the Recipient of the Transplantation of Burned Skin.*

In this group of experiments the burned skin from the abdomen and lower chest of dogs was transferred aseptically to normal dogs from which skin had been removed. In no one of the ten experiments was there evidence of viability of the transplanted skin. No evidence of toxæmia in the recipients was found.

FATAL BURNS—CAUSE OF DEATH

GROUP II.—*The Effects of Débridement on the Survival Period of Burned Dogs.*

In this group in all instances experiments on two dogs of approximately the same weight were performed simultaneously. The area of burned skin and the length of time that the heat was applied was approximately the same for both animals. Large amounts of morphine supplemented by ether at the time that the heat was applied were used as the anæsthetic. After intervals of time varying from twelve to twenty minutes the burned skin was removed from one of the dogs, while that of the other animal was not disturbed. The

TABLE I

The Effects of the Removal of Burned Skin on the Survival Period of Dogs

Series A. Skin Removal

Exp. #	Weight Kg.	Duration of Burning Minutes	Area of Burn Sq. Cm.	Time Interval Between Burn and Removal Minutes	Mean Blood Pressure Mms. Hg.				Survival Period After Burn Hours
					Before Burn	After Burn	Before Removal	After Removal	
1	6.25	21	246	15	94	108	108	86	9
2	5.6	21	221	15	92	94	94	112	4½
3	3.7	12	144	20	62	62	62	60	2
4	7.4	21	293	15	86	40	40	20	½
5	8.8	15	175	15	130	140	140	126	14
6	8.5	15	173	12	90	112	112	100	15½
Average	6.72	17.5	208	15	92	92	92	84	7½

Series B. Skin not Removed.

1	6.35	21	258	No Removal	112	110			10
2	5.2	21	205	No Removal	26	44			12½
3	3.35	12	161	No Removal	80	94			7½
4	7.35	21	290	No Removal	106	90			4
5	8.43	15	166	No Removal	132	142			54
6	8.8	15	173	No Removal	126	150			15½
Average	6.58	17.5	208		97	105			17½

arterial blood-pressures of each were measured frequently and the survival period was determined. Six such "double" experiments were performed.

In most of the experiments the blood-pressure was slightly higher immediately after the animals had been burned than it had been before the heat was applied. The mean blood-pressure was determined immediately before and immediately after the removal of the burned skin. In five of the six experiments, the dog on which the skin was left intact lived longer than the one from which the skin was removed. In the remaining experiment, the two animals lived the same length of time. The average survival period of the dogs upon which débridement had been performed (Series A) was seven and one-half hours, while that of the other series (Series B) was seventeen and one-half hours. The results of these experiments are given in Table I.

GROUP III.—*The Effects of the Transfusion of Blood from Burned Dogs to Normal Dogs.*

In this group, consisting of fifteen experiments, blood from the femoral arteries of dogs which had been burned was injected into the femoral veins of normal dogs by direct multiple syringe method using aseptic technic. The duration of the burning varied from three to twenty minutes. The time interval separating the burn and the transfusion varied in order to study both the early and late effects of blood from a burned animal. This interval varied from one and one-half to ninety-one hours, the average being twenty-nine hours. In most of the experiments all of the blood that could be obtained from the donor was given to the recipient. The amount of this blood varied in the different experiments from 200 to 400 cubic centimetres. In two experiments the recipients were bled 200 cubic centimetres before they received blood from the burned dog. No matching or typing of the blood was performed. In most of the experiments the blood-pressure of the recipient was determined immediately before and after the transfusion, and after an interval of time varying from seventeen to twenty-four hours had elapsed. The blood-pressure cannula was then removed and the incision was closed.

Of the fifteen recipients one died immediately after transfusion. The blood pressure of this animal fell markedly after 200 cubic centimetres of blood were removed and it continued to fall when transfusion with blood from the burned dog was performed. In all experiments except the one just mentioned the blood-pressure of the recipient was higher after the transfusion than it had been previously. One dog died ten hours after the transfusion. Autopsy revealed thrombosis of the right femoral vein and a pulmonary infarct. These may or may not have caused the death. One dog developed bronchopneumonia. This animal was killed three days after the transfusion. The remaining twelve animals lived and showed no ill effects from the transfusions.

Discussion.—An attempt was made in these experiments to determine whether or not death after superficial burns is due to toxæmia. Robertson and Boyd⁷ found that rabbits which had burned skin transplanted to them developed toxic symptoms within an hour. In the present experiments the injured skin which was transplanted from burned to normal dogs showed no evidence of a blood supply having been established and simply sloughed off. There was no evidence of toxæmia resulting from the transplant. Dogs upon which débridement of burned skin was performed lived for shorter periods of time than animals of the same weight with burns of the same extent and severity in which the burned skin was not removed. Dogs do not blister when burned and weeping from the skin is inappreciable, hence the skin serves as a barrier against the loss of fluid. When burned skin is removed probably more fluid is lost than is the case when the skin is left intact, because the operation for the removal of skin is associated with the loss of a small amount of blood, and, too, a denuded surface remains from which fluid escapes. No definite evidence of the presence of toxins was obtained

in the experiments in which whole blood from burned dogs was transferred to normal dogs.

Summary.—All of the experiments were performed on dogs that were profoundly anæsthetized. Burned skin when transplanted to normal dogs did not remain viable and no evidence of toxæmia was found in the recipients. Dogs in which the burned skin was removed had a shorter survival period than others of the same weight with burns of the same extent and severity from which the burned skin was not removed. Whole blood that was transferred from burned to normal dogs did not cause untoward symptoms in most of the recipients.

BIBLIOGRAPHY

- ¹ Avdakoff: Dissertation St. Petersburg, 1876. (Quoted by Bardeen.) Reference 6.
- ² Kizanitzin, J.: Zur Frage nach der Ursache des Todes bei Ausgedehnten Hautverbrennungen. Arch. f. Path. anat., vol. cxxxi, p. 436, 1893.
- ³ Pfeiffer, H.: XX. Experimentale Beiträge zur Ätiologie des primären Verbrennungstodes. Arch. f. Path. anat., vol., clxxx, p. 367, 1905.
- ⁴ Vogt, E.: Versuche über die Uebertragbarkeit des Verbrennungsgiftes. Zeitschrift f. Exp. Path. u. Therap., vol. xi, p. 191, 1912.
- ⁵ Weiskotten, H. G.: Histopathology of Superficial Burns. Jour. Am. Med. Assn., vol. lxxii, p. 259, 1919.
- ⁶ Bardeen, C. R.: A Review of the Pathology of Superficial Burns with a Contribution to Our Knowledge of the Pathological Changes in the Organs in Cases of Rapidly Fatal Burns. Johns Hopkins Hospital Reports, vol. vii, p. 137, 1898.
- ⁷ Robertson, B., and Boyd, G. L.: The Toxemia of Severe Superficial Burns. Journ. Lab. and Clin. Med., vol. ix, p. 1, 1923.
- ⁸ Underhill, F. P.: Changes in Blood Concentration with Special Reference to the Treatment of Extensive Superficial Burns. ANNALS OF SURGERY, vol. lxxxvi, p. 840, 1927.
- ⁹ Blalock, A.: Experimental Shock. VII. The Importance of the Local Loss of Fluid in the Production of the Low Blood Pressure after Burns. Arch. of Surg., vol. xxii, p. 610, April, 1931.
- ¹⁰ Beard, J. W., and Blalock, A.: Experimental Shock. VIII. The Composition of the Fluid Which Escapes from the Blood Stream After Mild Trauma to an Extremity; After Trauma to the Intestines; and After Burns. Arch. of Surg., vol. xxii, p. 617, April, 1931.

EMBOLECTOMY

REPORT OF A CASE INVOLVING THE FEMORAL ARTERY
BY EDMUND ANDREWS, M.D., AND HENRY HARKINS, M.D.
OF CHICAGO, ILL.

FROM THE DEPARTMENT OF SURGERY OF THE UNIVERSITY OF CHICAGO.

THE operation of embolectomy was first attempted by Ssabenejew¹ in 1895, but he did not find the embolus. Lejars² removed an arterial thrombus in 1902. Twelve embolectomies were done before George Labey³ did the first successful one in 1911. In 1912 Einar Key,⁴ of Stockholm, performed the first of his series of seventeen embolectomies on fifteen patients.

Reviews of the literature are given by Key,⁴ in 1922, quoting thirteen successes out of forty-five cases; Jefferson,⁵ in 1925, quoting twenty-eight successes out of seventy-three cases; Petitpierre,⁶ in 1928, quoting thirty-four successes out of 118 cases; and Key,⁷ in 1929, quoting approximately eighty-six successes out of 216 cases. At least fifty-two embolectomies have been done since Key's last review. Key's article in 1922 is the classic in the field of embolectomy and so great has been his influence that of the 216 cases collected to the end of 1927, 145 were done in Sweden. American and English reviewers agree on the preponderance of Swedish cases and Pemberton⁸ states that up to 1928 only twenty cases were reported in the United States and Canada.

Various instruments, including alligator forceps, Babcock's vein probes, uterine sounds, ureteral catheters, small urethral catheters, and Merke's corkscrew probes have been used to remove the emboli. In 1894, Severeanu⁹ suggested that in cases of amputation for gangrene due to arterial obstruction, a bougie might be passed up for some distance from the cut surface of the stump into the divided proximal end of the main artery so as to insure its patency, to remove clots, and to minimize the risk of gangrene of the flaps. We could find no report in the literature of using a large urethral catheter.

Despite the ultimately poor result, we are reporting the present case (1) because of the relative lack of interest in embolectomy outside of Sweden, and (2) because the embolus was removed in a new way.

CASE REPORT.—Mrs. A. S., aged sixty-four, white, housewife, with two children living and well, entered the Chicago Lying-In Hospital on November 12, 1931, with the complaints of a dropping sensation in the vagina, dyspnoea on slight exertion, and almost total deafness, all of several years' duration. The family history and past history were uneventful. She had reached the menopause at forty-seven and her three complaints had gradually developed since then. She had been seen once before in the outpatient department on October 5, 1931, when the symptoms and examination were the same as on entrance to the hospital.

The patient appeared older than she really was. There was a little dyspnoea when she was lying flat, but no cyanosis. The lungs were normal. The left heart border

was in the anterior axillary line. There was a systolic murmur at the apex transmitted to the axilla and a systolic murmur at the base transmitted to the neck. The second sound at the base on the right was accentuated and there were frequent extrasystoles. The liver was just palpable and there was no fluid in the abdomen. Vaginal examination revealed an anterior and posterior colpocoele, uterine prolapse, and cervical erosion. The temperature was 98.0° F., the pulse rate 80, the respiratory rate 22, and the blood-pressure 194 systolic and 100 diastolic.

Course.—On November 16 there was some pain beneath the sternum and an electrocardiographic tracing indicated coronary occlusion and left axis deviation. On November 19 a La Forte colpocleisis was done under local anæsthesia. The patient improved after this operation until November 27 when she had severe pain beneath the sternum with nausea, vomiting, cyanosis, and a chill. The pulse was absolutely irregular and the blood-pressure, 150 systolic and 94 diastolic. A diagnosis of coronary embolism was made. Two days later she had a pain in the right chest with blood-tinged sputum, a friction rub, and a fever of 101° F. Again on December 8 she had blood-tinged sputum.

December 11 there was pitting œdema of the left leg.

December 12 there was pain in the left popliteal region. The dorsalis pedis pulsation was palpable.

December 13 there was tenderness over the left femoral vessels and in the left calf and a diagnosis of thrombophlebitis of the left leg was made.

December 14 the patient had great pain in the left leg. The skin below the knee became mottled and of a violaceous tint. The patient tossed about and was covered with cold perspiration.

December 15 she had a sudden attack of violent pain in the left leg at 11 P.M. The leg became colder and more mottled. It is believed that the embolism occurred at this time and that the symptoms during the few days just preceding were due to small emboli, or to the main embolus lying higher up in the artery without completely obstructing it. Key⁷ has shown that small emboli often precede the major one.

December 16 at 11 A.M. we saw the patient. The left dorsalis pedis and popliteal pulsations were not palpable. The leg was mottled to about 10 centimetres above the knee and skin temperature tests showed the maximum point of change to be also about 10 centimetres above the knee. A diagnosis of embolism of the left femoral artery was made and at 2 P.M., about fifteen hours after the lodging of the embolus, an arterial embolectomy was performed. Because of the palpable femoral pulsation just below the inguinal ligament, a popliteal approach was used.

Operation.—Under novocaine anæsthesia, a longitudinal incision about 15 centimetres long was made in the upper portion of the left popliteal fossa. The femoral vein was thrombosed and the artery empty and pulseless. The lower portion of the operative field did not bleed, but in the upper angle of the wound several vessels had to be clamped and more novocaine injected. The femoral artery was opened by a longitudinal incision about 2 centimetres long and a probe passed up the artery for 12 centimetres. A clot about 1 centimetre long came out with the probe. There was some liquid blood in the artery at the site of incision and below. A probe passed 12 centimetres down the artery met no obstruction. A No. 18 soft urethral catheter was then passed 24 centimetres up the artery. The catheter filled the lumen of the artery and the lower end of the catheter was clamped with a hæmostat. It was then removed rapidly and acting like a piston, pulled out a smooth, grayish-red clot about 6 centimetres long. Almost immediately blood gushed from the arteriotomy wound and spurted several feet across the room (systolic blood-pressure varied between 115 and 145 during operation). At the same time numerous points in the operative field began to bleed. The arteriotomy wound was closed with two layers of continuous fine silk suture and was quite dry after closure. Arterial pulsation was palpable below the point of repair

of the artery. The vein was ligated. The wound was closed in the usual manner except that the popliteal fascia was not united.

Post-operative Course.—There was no palpable pulsation in the dorsalis pedis artery at any time after operation, but the femoral pulsation remained present. The day after operation the point of sudden change in the skin temperatures was about 15 centimetres below the knee. Two days after operation this point was about 5 to 10 centimetres below the knee and it remained there until the day before death.

December 18, two days after operation, several vesicles appeared on the foot.

December 20 pain sensation as determined by a pin prick was absent a hand's breadth below the tibial tubercles. There was a recurrence of pain in the right chest.

December 23 the foot and half the leg were purple and the toes shrunken. Several blebs had broken and were dusted with boric acid powder.

December 26 the skin stitches were removed. The wound had healed nicely and there was no necrosis of the skin edges.

December 28 the patient expired suddenly. At the time of death there was a definite line of demarcation about 15 centimetres below the knee. No necropsy was permitted.

Comment.—It is probable that the embolus in our patient was in the femoral artery at the point where the profunda femoris branches off. The catheter was inserted 24 centimetres above the arteriotomy and thus would approximately reach the junction with the profunda. This junction lies about 4 centimetres below the inguinal ligament and could be occluded even though the femoral pulse is palpable. Nordentoft¹⁰ states that there may be a pulsation directly over an embolus due to the downward thrust of the embolus when hit by the pulse waves from above. It is also possible that the upper end of the embolus might not completely obstruct the artery and thus the pulsations could go below the upper end of the embolus. It is also possible that at one time the embolus in our patient straddled the bifurcation of the aorta.

In using the large catheter, a snug fit is necessary. Embolectomy is often required in patients with pipestem vessels. Nyström¹¹ reported a case of forcing a false passage in a very arteriosclerotic vessel with a metal probe.

It is well known that one of the chief benefits of embolectomy may be in opening up the collateral circulation. This is especially true since emboli usually lodge at arterial bifurcations. In all of Lahey's four cases¹² and in 41.8 per cent. of Petitpierre's 118 cases,⁶ the embolus lodged in the femoral artery where the profunda branch is given off. It is almost as important to remove any secondary thrombi at the point of ingress of collateral circulation as to remove the embolus at the point of egress. Thus it would be important to have the openings of the genu superior arteries open as well as to have the profunda femoris artery patent in the case of an embolism of the femoral artery. It is possible that in our patient the profunda femoris opening was freed at the time of operation, but that a thrombus reformed in the popliteal region.

This case brings out several points emphasized by previous authors. It illustrates that arterial emboli may occur in cardiac disease, that removal of an embolus more than ten hours after the onset of symptoms usually does

EMBOLECTOMY

not restore the limb, that multiple emboli often occur, that the operation itself is not necessarily a difficult one, and, finally, that embolectomy may lower the apparent line of demarcation in an impending gangrene even if the entire extremity is not saved. We found that a large soft urethral catheter was effective in removing the embolus.

BIBLIOGRAPHY

- ¹ Ssabanejew: Cited by Key. *Russki Chir. Arch.*, 1895.
- ² Lejars, F.: De l'attrition sous cutanée directe des grosses artères. *Bull. et Mém. Soc. de Chir. de Paris*, vol. xxviii, pp. 609-619, May 21, 1902.
- ³ Mosny and Dumont: Embolie fémorale au cours d'un retrecissement mitral pur; Arteriotomie, guérison. *Bull. Acad. de Méd., Paris*, 1911, p. 358. Cited by Key. This case is usually attributed to Mosny and Dumont who diagnosed it and published it. George Lahey did the operation, but in several recently published papers this is misspelled as Lahey.
- ⁴ Key, Einar: Über Embolectomi als Behandlungsmethode bei embolischen Zirkulationsstörungen der Extremitäten. *Acta. Chir. Scandinav.*, vol. liv, pp. 339-416, 1921-1922.
- ⁵ Jefferson, Goeffrey: Report of a Successful Case of Embolectomy with a Review of the Literature. *Brit. Med. Jour.*, vol. ii, pp. 985-987, 1925.
- ⁶ Petitpierre, M.: Über Embolektomie der Extremitätenarterien. *Deutsche Ztschr. f. Chir.*, vol. ccx, pp. 184-238, 1928.
- ⁷ Key, Einar: Die Embolieoperationen auf Grund der bisherigen Erfahrungen. *Ergebn. d. Chir. u. Orthop.*, vol. xxii, pp. 1-94, 1929.
- ⁸ Pemberton, J. DeJ.: Embolectomy. Report of Three Cases. *ANNALS OF SURGERY*, vol. lxxxvii, pp. 642-656, May, 1928.
- ⁹ Severeanu: Le Cathétérisme des Artères. *Progrès. Méd.*, No. 32, 1894. Cited by Handley, W. S., *Brit. Med. Jour.*, vol. ii, p. 712, September 21, 1907.
- ¹⁰ Nordentoft, J.: Two Cases of Embolectomy. *Hospitaltid.*, vol. lxxii, pp. 55-61, January 17, 1929; abstr., *Jour. Am. Med. Assn.*, vol. xcii, p. 1900, June 1, 1929.
- ¹¹ Nyström, Gunnar: Zur Prognose und Methodik der Embolektomie. *Acta. Chir. Scandinav.*, vol. lx, pp. 229-254, 1926.
- ¹² Lahey, F. H.: The Treatment of Emboli in the Peripheral Vessels. *S. Clin. N. America*, vol. vi, pp. 651-666, June, 1926.

EMBOLECTOMY WITH PARTIAL ARTERIAL OCCLUSION FOR EMBOLISM OF THE EXTREMITIES

BY HAROLD NEUHOF, M.D.

OF NEW YORK, N. Y.

FROM THE SURGICAL SERVICE OF THE MOUNT SINAI HOSPITAL

CARREL's classical experiments in arterial suture were a natural stimulus to operations for the removal of emboli blocking arterial pathways in human beings. Compared with some of his complicated vascular operations, the incision of an artery, removal of the clot, and the suture of the vessel appeared a very simple procedure from which excellent results could be anticipated. The literature soon contained enthusiastic reports with details on technic and indications. The operation appeared destined to be a vital contribution to the recovery of circulation and of limb in early cases of embolism in the extremities. Fewer and fewer reports on the operation have appeared in the literature in recent years; so much so that one gains the impression that a procedure with such great promise of brilliant results has been largely discarded. My purpose is not to revive interest in the original operation of embolectomy. I propose to analyze the reasons for failure, to present a somewhat different viewpoint, and a modified procedure that appears to offer an outlook for better clinical results.

The restitution of the arterial stream is the primary object of embolectomy and arterial suture. It is quite impossible to determine how often that has occurred in the reported cases. The saving of all or most of a limb is no evidence that a through circulation of blood has occurred at the site of the embolectomy. In fact, there are so few instances in which the explicit statement of a permanent return of arterial pulsation is made that it is fair to assume that there was no lasting through arterial stream after the great majority of the operations. Operations are often termed successful when no gangrene or only limited gangrene supervenes. The literature consists, for the most part, of individual case reports of this kind; the proportion of total failure to such successful outcomes is unknown. There are, however, enough instances of satisfactory results in the absence of through circulation at the site of suture to justify the operation on that basis alone.

The surgery of arterial embolism has obviously fallen short of the ideal. The reasons should now be considered. The customary argument is that the operation must be done early and that the sooner after lodgement of the embolus the operation is performed, the better the outlook for a result. This argument is based on the assumption that characteristic and recognizable symptoms occur at the moment the embolus becomes strapped in the vessel. I see no logical ground for this view. The embolus, usually lodged at a bifurcation or at the site of a large branch leaving the artery, should

not in itself produce any significant clinical manifestations. It is only when the added thrombus becomes large enough to occlude the vessel that the characteristic symptoms should appear. The undetermined interval of time may render even an assumed early and favorably considered case a late one in fact. The hazards attending arterial suture after embolectomy, which will now be discussed, therefore apply with equal force to so-called early operations. The reaction in the arterial intima that has already occurred at the site of the embolism precludes the smooth type of repair after arterial suture that is seen in the experimental animal. Additional thrombi at the site of suture are probably inevitable. Their danger lies in the likelihood of dislodgement by the blood-stream and blockage at more distal sites. The more peripherally located the occlusion the less the chances for collateral circulation and the greater the chances for gangrene. In one of my cases at Mount Sinai Hospital a satisfactory immediate return of through arterial circulation followed removal of an embolus from the common femoral artery. Subsequently the pulses at the ankle disappeared, gangrene supervened, and the leg was amputated above the knee. Dissection of the amputated limb disclosed a recent large thrombus occluding the popliteal artery at its bifurcation. The danger of a dislodged thrombus attends any embolectomy with restoration of the circulation. Additional factors inviting post-operative thrombosis are the altered intima when arteriosclerosis or chronic valvular disease exists, and operations upon infected emboli. Under the last-mentioned circumstances an infected thrombus at the site of suture is of course potentially a much graver menace than the ordinary bland clot. The rôle of operative technic must also be mentioned. Massive thrombosis after embolectomy can be predicted if all the niceties of technic are not observed. In none of the cases in my experience was there restitution of the arterial stream when additional sutures to control leakage were required after the occluding clamps on a sutured artery were removed. Not only is a thorough training in experimental arterial work essential for the adequate execution of embolectomy, but also the opportunity for the performance of the operation occurs but rarely in surgical practice.

For all these reasons embolectomy with suture of the artery can only offer a small proportion of satisfactory results. Indeed, a careful reading of the literature leads to the conclusion that results would have been as good in not a few of the reported cases had operation not been performed. In my own experience of a dozen or more cases there is but one satisfying outcome to balance an otherwise unbroken series of failures. A girl suffering from mitral stenosis was operated upon shortly after the onset of symptoms of blockage of the popliteal artery. Permanent through circulation followed embolectomy and suture. The pulses at the ankle remain small and there are manifestations of claudication on prolonged walking. It is of interest to note that at the time this case was demonstrated I also presented a patient on whom I had operated at Mount Sinai Hospital, performing an obliterative aneurismorrhaphy for an aneurism of the popliteal artery following a gun-

shot wound. The operation was an urgent one because of gangrene of one toe and impending gangrene of the remainder of the foot. This patient attends to his occupation, involving much walking, without any symptoms, although his popliteal artery is obliterated. The failures in my cases of embolectomy were total failures, the customary amputation for gangrene being required in every instance. In retrospect there were two or possibly three cases that might have done better if operation on the artery had not been performed. It was the analysis of my own experience, and, in particular, the quoted case of proven detachment of a thrombus with blockage of the popliteal artery, that led me to take a more conservative view of the subject of embolectomy.

At the present time I believe that operation should be undertaken for embolism involving the arteries of the extremities only when the diagnosis and localization are certain and the evidence points clearly to the likelihood of massive gangrene if blockage is not relieved. A discussion on diagnosis is out of place. It can be said, however, that there should be a more general appreciation of the fact that the diagnosis is not always simple or the accurate localization of the embolus easy. I have operated twice for supposed embolism of the common femoral artery to find that the obstruction was at a much higher level, and on one occasion operated for embolism of the abdominal aorta at its bifurcation when the patient was later found to be suffering from widespread venous thromboses in both lower extremities. There must be clear clinical evidence that massive gangrene will occur if the embolus is not removed. In recent years I have observed several cases in which the decision to await further developments was made because such evidence did not exist. The early furious manifestations were followed by subsidence and by partial or complete restoration of circulation through collaterals (or possibly by canalization of the thrombus). I would call special attention to the saddle embolus at the bifurcation of the abdominal aorta. On the one hand the patient is usually in a state of severe shock and the operation is a formidable one. On the other hand I have seen instances of complete or partial restoration of circulation by awaiting developments. It is questionable in my opinion whether operation should ever be attempted on the abdominal aorta for an embolus lodged at that site.

There remain enough instances of embolism involving the arteries of the extremities in which the indication for operation is imperative. Having called attention to the reasons for failure in the ideal operation I wish to present a modified procedure and to report the case in which it was employed. The embolus with its surrounding thrombus is usually wedged in the long axis of an artery where the artery is angulated or narrowed by an important branch that is given off. If this branch could be saved for collateral circulation gangrene might be obviated. The branch is probably saved in the ideal operation at the risk of thrombi that can be swept into the peripheral distribution of the parent trunk. Theoretically, therefore, it would be better to remove the embolus, suture the incision in the artery, and ligate the artery

below the branch. This, however, might force new-formed thrombi into the branch and render gangrene certain. It occurred to me that a solution of the problem would be an operation that can be generally employed and is not limited to those trained in the Carrel technic. The plan is as follows: After the exposure of the artery a liberal vertical incision is made over the thrombus on the side away from the branch. The incision is extended as freely as desired (particularly in the peripheral direction) so that the whole embolus can extrude without any manipulations. The lips of the wound in the artery are then broadly approximated by mattress sutures (of ordinary fine silk) that appreciably reduce the lumen of the vessel. With this technic minimal thrombosis should occur because of broad intimal approximation, and leakage at the suture line should not take place. The reduced calibre of the lumen would prevent peripheral dissemination of larger thrombi if they formed. Such thrombi would lodge in the narrowed artery below the branch and probably obliterate the lumen, leaving the branch free to carry collateral circulation. The closure of the lumen would probably be gradual, allowing some opportunity for the development of anastomosis. The plan was carried out in the following case operated upon at Mount Sinai Hospital:

A man seventy-three years old had been under treatment for two weeks for (a probable) auricular thrombosis. The course was satisfactory until 9 A.M., June 27, 1930. There was then a sudden onset of violent pain in the right hand and arm, the hand rapidly became bluish and cold, and the patient was soon unable to move either the hand or the forearm. His chief complaint was persisting severe pain in the right hand. There was cyanosis from mid-forearm down to and including the hand. The nails and fingertips were a deep blue. The whole extremity was cold. There was complete loss of function of the hand and wrist, partial loss of power at the elbow and shoulder. Sensation was also completely lost in the distribution of the ulnar nerve in the hand, and greatly reduced in the remainder of the hand. There was partial sensory loss over the forearm. The patient was suffering too severely to warrant mapping out the sensory fields. No pulsation was to be felt in the arteries at the wrist, elbow and arm up to the junction of the axillary and the brachial arteries. Here powerful pulsation was felt in the third portion of the axillary artery, ceasing abruptly at the lower border of the pectoralis major. The following is a transcript of the pre-operative note on the chart: With the diagnosis clear, the elapsed number of hours (patient seen at 1:30 P.M., that is four and one-half hours after the onset of symptoms) made the operative indication questionable. On the one hand the violent pain and apparently inevitable gangrene warranted an effort at relief. On the other hand the patient's advanced age and the possibility of other embolic phenomena were deterrent factors. It was, however, decided to perform an embolectomy with partial or complete obliteration of the artery, dependence to be placed on collateral circulation.

Operation was performed under local anæsthesia, six hours after the onset of symptoms. An incision was made over the lower part of the axillary artery and carried down over the upper portion of the brachial. The free margin of the pectoralis major was retracted. A large thrombus, broader below and distending the artery, could be seen as well as felt. Its situation obviously led to blockage not only of the axillary artery, but also of the branches from its third portion (the subscapular and circumflex arteries). The thrombus terminated below at the site of the superior profunda branch of the brachial artery. Dissection of the branches was not carried out. Serrefines were applied to the axillary and brachial arteries above and below the thrombus. A longitudinal

incision was made over the lower part of the thrombus and was progressively enlarged upwards so that the final opening in the artery was about 4 centimetres long. The thrombus began to extrude spontaneously upon incision of the vessel and broke off when about half had escaped. The upper serrefine was then released and the remaining half extruded, followed by a violent jet of blood. The serrefine was reapplied. The thrombus, about 5 centimetres long, was examined and found to be complete. The incision in the artery was then closed. Closure was by continuous mattress sutures making broad approximation of the intima. The arterial lumen was thereby narrowed by about one-half. When the serrefines were removed only a thin arterial stream could be felt below the suture line.

Directly after operation the hand and arm were less cold and cyanotic. A small radial pulse felt a few hours after operation was not perceptible the next day and at no time in the subsequent course was pulsation to be felt over the brachial or more peripheral arteries. The day after operation the pain in the hand and arm had disappeared, cyanosis was much less evident, the hand and arm were still cold, and there was beginning return of sensation. On the second day after operation there was considerable improvement in color and in the return of power. Four days after operation the hand and forearm were approximately normal. There was normal sensation and motion, and good color. The hand was warm, but not as warm as the left, and was also somewhat paler. The hand was normal one week after operation, when the patient was discharged from the hospital. Since that time there have been no manifestations referable to the arterial occlusion. The last report I have on the patient is one year after operation, at which time he was symptom-free as far as the right upper extremity was concerned.

Summary.—It is probable that the restitution of the arterial stream occurs only rarely after embolectomy and arterial suture.

So-called early operations for the removal of emboli may, in fact, be late ones.

The causes for failure are already existing changes in the arterial intima at the site of embolism, technical flaws at the time of operation, and the dislodgement of thrombi after operation.

Successful operative results are usually termed those in which gangrene does not supervene, but the same results might have occurred without operation in cases in which through arterial circulation did not follow embolectomy.

Operation for embolism of the arteries of the extremities is indicated only when the diagnosis and localization are certain and the evidence points clearly to the likelihood of massive gangrene if blockage is not relieved.

In order to reduce the chances of thrombosis and peripheral dissemination of thrombi after operation a modification of the customary operation is advocated, consisting in evacuation of the embolus and broad approximation of the arterial intima with resultant narrowing of the lumen. Its successful application in one case is described.

INSULIN AND SURGERY *

BY PAUL D. ABRAMSON, M.D.

OF SHREVEPORT, LA.

THE advent of a therapeutically useful insulin has marked a definite advance in the progress of medicine. Since its discovery the treatment of diabetes and its surgical complications has been vastly revolutionized, with a concomitant marked improvement of the prognosis. As it has been aptly remarked, the researches of Lister and Pasteur made surgery safe for diabetics and it but remained for Banting, MacCleod and their co-workers to make diabetics safe for surgery. We are herein concerned with a consideration of the surgical aspects of insulin; while, undoubtedly, its greatest value thus far is in the management of diabetes, and the related non-diabetic acidosis, still there is every reason to believe that with further observations as yet unsuspected uses for this powerful substance will be found. Already it has been found of value in conditions totally unrelated to diabetes, though in all fairness it must be admitted that there is little evidence to support some of the claims that have been made regarding the therapeutic value of insulin in various and sundry conditions.

There is no more interesting and intriguing chapter in medical history than the absorbing story of the near-successes, the bitter disappointments that have marked the attempt to isolate the active hormone of the isles of Langerhans. Even before Langerhans had described the islets which have come to bear his name (1869), Cowley (1788) and the French physician Bouchardat (1845) had definitely shown the relationship between the pancreas and diabetes. Even after Minkowski and von Mering, in 1889, were successful for the first time (with the possible exception of von Brunner in 1683) in producing diabetes in the experimental animal by extirpating the pancreas, these islets were not incriminated as being related to diabetes. However, Laquesse's and Diamare's observations in the laboratory, and the mounting evidence collected by pathologists, finally convinced scientists that it was in these little pancreatic islands that the substance or hormone related to diabetes was produced. This substance was labeled "insulin" by Sir Sharpey Schafer, in 1916.

One of the most arresting episodes is the work of Zuelzer, in 1907. If he had not been too anxious to try his product clinically, in all probability insulin would have been available in 1908, or thereabouts. Recognizing that the pancreatic ferments destroyed the hormone of the islets (later called insulin), he made alcoholic extracts of the pancreas, not unlike the method used later by the Toronto workers. Using this product intravenously he got such severe reactions that its use was abandoned. We now know these

* Read before the Shreveport Medical Society, November 3, 1931.

reactions to have been the result of hyperinsulinism, and if the laboratory animal had first been used to standardize the product before clinical trial, they would likely have been avoided and the researches continued. Just think of the possibilities if insulin had been "discovered" in 1908 instead of 1922! Rennie and Fraser had, a number of years previously, in all probability isolated the hormone, but they unfortunately used it by mouth, and as is now well known, this destroyed the ferment.

It was not until 1921 that Banting, Best and later MacCleod and Collip initiated their researches which two years later resulted in the production of a commercially practical insulin. After its discovery it was immediately seized upon by clinicians not only in the treatment of the medical diabetic, but it was hailed as a saviour for the surgical diabetic. Calmer judgment has rationalized and more clearly systematized its use, has more definitely defined its limitations and dangers, though at the same time extending its scope of application into related fields.

As is well known, insulin is the active principle secreted by the pancreatic islands of Langerhans. There are, however, several other interesting features about it which are not as generally appreciated. While undoubtedly these isles are the chief source of this hormone, it has been found present in practically every structure of the body where carbohydrate metabolism occurs. Best and Scott⁵⁸ have prepared insulin from the submaxillary, thymus, thyroid, spleen, muscle, liver and other tissues, while Livierato⁷² has found it in the tonsil. It has been found⁵⁸ that the muscular system of a dog contains twenty times as much insulin as does its pancreas, the blood five times as much and the liver fully as much as the pancreas. This apparently indicates that insulin acts at the site of eventual utilization of carbohydrates. While some believe that insulin can be formed locally in the tissues, it is certainly more logical to suppose that it is formed in the pancreas and carried to the various tissues by the blood-stream. Undoubtedly the pancreas not only forms insulin but acts also as a storehouse: enough of the hormone can be recovered from a dog's pancreas that if re-injected it kills by a hypoglycæmic reaction. Substances apparently related to insulin have been isolated from yeast, onions and other vegetable sources. Collip²⁰ has called these related vegetable extracts "glucokinin," though it is not definitely known that these are identical with the product from animal sources.

As a matter of fact, a great deal more is known about *what* insulin does than about how it does it. Theories are legion as to its actions, what phases of metabolism are influenced, *etc.*, but while it undoubtedly does influence water metabolism, metabolism in general, as well as the digestion of fats and proteins, apparently its more important, and certainly its better understood function is its rôle in carbohydrate digestion, though its exact *modus operandi* remains somewhat obscured. Normally, the various carbohydrates are, in the process of alimentary digestion, ultimately broken down into the simpler sugars, or monosaccharides, chiefly glucose (dextrose). In this form it is absorbed from the intestines and passes through the portal circulation to the

liver where it is synthesized into glycogen and stored. Apparently glycogen is, as required, broken down into glucose again, carried to the various bodily structures by way of the general circulation, and there resynthesized into glycogen and stored, where it is ready for immediate usage. Possibly glycogenolysis, or the conversion of glycogen into the simpler sugars, occurs continuously in the liver whether or not insulin is available (though Schmidt¹⁰⁷ and others have offered evidence to the contrary). Normally this glucose, which is thus thrown into the blood-stream, is continuously removed by the action of insulin in the various tissues of the body, where it aids in the removal of this glucose from the blood and its peripheral utilization. Insulin does not actually help burn the glucose; its action is probably anabolic in nature, converting the glucose from the blood into glycogen in the tissues, which is a necessary step before the sugar can be utilized. If insulin be lacking in the body economy, or if it be deficient, only partial utilization, or burning, of the glucose occurs, and its removal from the blood-stream does not keep pace with that thrown into the vascular system from the process of hepatic glycogenolysis. As a result, glucose accumulates in the blood in sometimes amazing quantities, and produces one of the most characteristic signs of diabetes mellitus, hyperglycaemia. If insulin is supplied it apparently causes a "vacuum"—to use Joslin's term—in the tissues for sugar (as a result of carbohydrate utilization) which is replenished by removal of the excess from the blood, the blood sugar thereby dropping to within more normal limits. Obviously, since the "vacuum" or need of sugar is greater in the tissues of the diabetic than in the normal individual, insulin causes a relatively more marked drop in blood sugar in the diabetic than in the non-diabetic. Insulin probably acts as a catalyst, rather than actually participating in the digestive processes, as is indicated by the fact that it can be injected into dogs and recovered almost *in toto* in the urine while still exerting its physiological effect. Admittedly, such a conception of the mode of insulin action is not positively proven, but it serves well enough for clinical purposes.

The classical expression to the effect that fats burn in the flame of the carbohydrates has never been equaled for clarity in explaining the intimate relationship between carbohydrate and fat metabolism. As the sugars are digested, oxygen is liberated, which serves to oxidize (burn) the fats. If carbohydrate digestion is ample, then sufficient oxygen is available to completely oxidize the fats into the end-products: carbon dioxide and water. If, however, there is deficient carbohydrate metabolism there is not enough oxygen available to completely oxidize the fats, resulting in the formation of intermediary products, the so-called acetone bodies: acetone, diacetic acid and B-oxybutyric acid. As a result of the accumulation of these acid substances in the body, there develops a condition of acidosis. Quite obviously, such an acidosis may result when, due to lack of insulin, available carbohydrate in the body cannot be utilized, or it may develop in a condition where, though insulin is ample, there simply is not sufficient carbohydrate present

in the body, as obtains in starvation. In effect the result is the same: partial fat digestion because of lack of sufficient carbohydrate digestion.

There is a point which needs some emphasis, and it is that the acidosis is of much graver significance than is the hyperglycæmia, which fact is sometimes forgotten. In fact, there is relatively little proof that the high blood sugar, in itself, is in the least harmful. Of much graver import is the acidosis and the cholesteræmia resulting from faulty fat digestion. Hypoglycæmia is a far more serious condition than is hyperglycæmia and produces marked clinical symptoms; if the blood-sugar level be sufficiently low, a fatal outcome may develop.

As the result of the disturbed metabolism existent in diabetes mellitus, certain abnormal substances collect in the blood and are excreted, in part, in the urine, so that proper examinations of the urine and blood lead to a detection of this disturbance. As a rule, too much dependence is placed upon the urinalysis, both for preliminary diagnosis and subsequent therapy, and this may result in some untoward consequences. There are many pitfalls in the proper interpretation of the urinary findings, and only dire necessity should ever force a physician to attempt to treat diabetes without at least one blood examination. As regards these pitfalls: in the first place, it must be remembered that the amount of glycosuria in no manner necessarily reflects the true concentration of the sugar in the blood. Renal threshold is such a variable factor in different individuals, and even in the same individual at different times, that the sugar content of the urine will frequently be misleading. Numerous cases have been observed in which the urine has been free of sugar, though concomitant blood examination reveals a sugar content of .2 per cent. or more. Likewise, many examples of alimentary glycosuria exist, or cases of low renal threshold, in which there is no actual diabetes mellitus, though there be sugar present in the urine. Allan and Vanzant² report three cases illustrating that even a combination of ketonuria and glycosuria is not necessarily diagnostic of diabetes mellitus. If an individual has renal glycosuria, with a normal blood sugar, there tends to be a loss of sugar from the body with a resulting incomplete fat digestion, not differing in its manner of production from that seen in starvation, and a ketosis may develop with ketonuria. In such a case, the administration of insulin further lowers the available carbohydrate and aggravates the condition. Neither does the presence of ketone bodies in the urine necessarily indicate an acidosis. It simply means that there is a disturbance of fat digestion, and an incomplete destruction of the fat fractions, but it does not invariably mean that an acidotic condition exists, though the two are frequently associated. An interesting fact is pointed out by Marriott,⁷⁷ and it is that the so-called acetone test of Rothera, using sodium nitroprusside, is in reality a very delicate test for the presence of diacetic acid, being considerably more sensitive than the ferric chloride reaction. However, most text-books give the nitroprusside reaction as a test for acetone. Moreover, Starr and Fitz¹¹⁴ claim that in certain cases of diabetes mellitus a severe acidosis exists with excretion, not of

acetone bodies, but of organic acids, not detectable by ordinary urinalysis. A severe acidosis may exist, then, without ketonuria.

Therefore, though urinalysis is invaluable in giving a clue to the presence of diabetes, the possible sources of error should be appreciated and guarded against, and confirmation by proper blood studies should be sought. Blood-sugar determinations are invaluable and should be the mainstay in the proper treatment of diabetes mellitus. Some observers¹²⁶ believe that cholesterol determinations are of more value than sugar determinations in the proper control of the diabetic, but this has not found very widespread application as yet. And in determining the presence or absence of acidosis, without question a carbon dioxide combining-power determination of the blood plasma is infinitely more accurate than a detection of the ketone bodies in the urine.

Insulin is marketed in this country standardized in units. This standardization is carried out by biological assay, that is, determination of the effect of a certain amount of insulin on a standard rabbit; more specifically, "the physiological unit at present is the amount of insulin necessary to reduce the blood sugar of a two-kilogram rabbit, deprived of food for twenty-four hours, to the convulsive level, 0.045 per cent., within five hours. The clinical unit is one-third of the strength of the physiological unit."⁵⁸ A unit of insulin thus determined is apparently rather consistent in its potency. However, it must be remembered that the fall in blood sugar is not necessarily proportionate to the amount of insulin used: that is, in proportion, smaller doses of insulin cause a greater fall in blood sugar per unit than do the larger doses. Estimates as to the glucose equivalent of each unit of insulin, that is, the amount of glucose metabolized by a unit of insulin, vary markedly, though the most generally accepted equivalent is about two and one-half grams of glucose per unit of insulin.

The only satisfactory way of insulin administration thus far developed which will have the proper and desired effect is by hypodermic. Though numerous attempts have been made to administer it intranasally,¹²⁵ through the skin by inunction,⁶⁹ under the tongue, by mouth, *etc.*, no satisfactory and reliable mode exists, unfortunately, other than by use of hypodermic injection. Of the three possible locations of making the injection, namely, intradermally (in the upper layers), subcutaneously, or thirdly, injection into the deeper fatty layers, the second, *i.e.*, subcutaneous injection, is the method of choice because it gives ample and consistent absorption of the insulin. Intracutaneous injection into the superficial layers, while acting more powerfully, is irritating and frequently causes an insulin "burn," apparently due to the tricresol added as a preservative; injection into the deeper fatty layers does not give uniform results. Intravenously injected, insulin exerts its influence rapidly and leaves the blood in two to four minutes. Subcutaneously, it reaches the maximum effect in about one hour after injection, continuing to act for about eight hours. This difference in action of insulin, depending upon which of these two routes is used for its administration, has been inadequately explained by Müller, *et al.*,⁸⁸ on the theory that

insulin acts only by stimulation of the cutaneous nerves, this effect being more marked and more prolonged by the subcutaneous than by the intravenous route. Different regions of the body are selected for the injections, the exact site being of little moment other than as regards convenience. Schmidt,¹⁰⁸ however, believes that certain tissues are capable of inactivating insulin by the action of proteolytic ferments, and he thus explains the occurrence of cases refractory to insulin therapy (*vide infra*).

It undoubtedly would be most desirable if a satisfactory method of insulin administration could be used in which a single, large dose might be given with a more gradual and prolonged action resulting. Such a method is claimed available by Strauch¹¹⁷ who uses a special oily preparation, an emulsion of water in oil, thus, according to him, permitting giving relatively large doses at infrequent intervals, each injection exerting its influence over a period of from five to seven days. Leyton,⁷¹ on the other hand, produces a similar, though less prolonged action, by dissolving the insulin in castor oil. Some¹⁷ reserve the use of the oily preparations for the graver forms of diabetes. These methods have not, as yet, found very widespread recognition, the more effervescent, watery solution still being the most universally used insulin.

Because the maximum effect of insulin is reached in one hour after subcutaneous injection, it is usually given one-half hour before a meal, as it takes the ingested carbohydrate one-half hour to be absorbed; thus the maximum absorbed glucose and insulin are present in the body at approximately the same time. Though most authorities agree that it is best to give insulin one-half hour before meals, some contend that the insulin should be evenly distributed every eight hours, regardless of meals.³⁸ Ordinarily, the aim sought is to regulate the patient so that two injections of insulin, before the morning and evening meals, will suffice.

Let us now turn to a more specific consideration of the usages of insulin in the surgical aspects of diabetes (mellitus). While we are herein more concerned with the surgical phases, it is easily understandable that there is no sharp dividing-line between the ordinary medical diabetic and the one suffering from surgical complications. Every diabetic is a potential surgical diabetic. Like Molière, "définissons nôt termes." A surgical diabetic is generally considered to be a diabetic in whom has arisen a condition amenable to surgical intervention. Such a condition may either be part and parcel of the diabetic picture, such as arteriosclerotic gangrene of the extremities, or it may be simply coincidental, such as in the case of appendicitis. As Joslin⁵⁹ has said, patients do not die of diabetes today, they die of its complications. Generally, a surgical diabetic is a serious diabetic. Since the advent of insulin, coma is no longer the bugbear in the management of the diabetic; it is the cardiovascular degenerative changes which now exact the greatest toll among these unfortunates. Joslin has also made the statement that "already every other diabetic is a surgical diabetic before he dies," so the extreme importance of the subject is self-evident.

There is no more impressive manner in which to illustrate the rôle that insulin plays in the surgery of diabetes than to compare the mortality in pre-insulin days with that of the Banting era. Weden, quoted by Joslin⁵⁸ had a pre-insulin operative mortality of 36.8 per cent., while his mortality since the introduction of insulin has been 16.6 per cent. Joslin's own figures do not show such a marked difference: between 1917-1923, his average mortality was 13.5 per cent., while since 1923 it has been 11.5 per cent. Lemann has found an insulin-era mortality of only 2.3 per cent. Bazin⁷ found a 2.74 per cent. mortality in diabetics with a 2.41 per cent. operative mortality in non-diabetics during the same period. White,¹²⁷ in a study of the records of the Roosevelt and New York Hospitals since the advent of insulin, found an operative mortality of 2.8 per cent. as contrasted with a 40 per cent. mortality prior to its use. Hauser and Foster⁴² vividly contrast the surgical prognosis of a diabetic thirty years ago and today, when at that time surgery was used only as a last resort in the presence of diabetes, while now no diabetic is denied surgery because of this disease. Truly insulin has made the diabetic safe for surgery!

There are several factors which are to be considered in any evaluation of the part that insulin has come to play in the treatment of the complications of diabetes. Whether or not it has any value prophylactically as regards surgical complications is not easy to determine. That is, whether or not the proper control of the medical diabetic, using adequate insulin to maintain him free from any marked hyperglycæmia, cholesteræmia, *etc.*, will prevent the occurrence of some of the complications is somewhat doubtful. Thus Wendt and Peck¹²⁶ believe that the adequate control will prevent many of the cutaneous manifestations such as furuncles, carbuncles, *etc.*, but express doubt as to whether it will prevent the vascular degenerative changes which account for many of the developments which add to the gravity of the diabetic state, such as gangrene, *etc.* As Warren¹²⁴ believes, susceptibility to cutaneous manifestations may be the result of abnormal glycogen deposits in the skin which are favorably influenced by insulin. The vascular changes that occur in a diabetic are identical with those of senility, but occur earlier in life due, according to many authorities, to a maintained high cholesteræmia. Certainly the proper control of the diabetes will not prevent senile changes occurring, whether it be in the blood-vessels or elsewhere, but it is logical to suppose that if it were possible to maintain a diabetic in an absolutely normal metabolic state (which is an ideal quite difficult of attainment) he would be immune from any of the degenerative changes occurring except as the result of natural senescence.⁶⁴ So there is at least some value prophylactically in the use of insulin, tending to some extent to prevent the development of some of the surgical complications.

Many are inclined to consider insulin a panacea, a cure-all, an excuse for carelessness of diet. There is no more pernicious thought prevalent today, regarding the treatment of diabetes, than that insulin is an excuse for negligence in the matter of dietary regulation. It most emphatically is not!

Its value lies in its use as an auxiliary measure. The proper attitude to assume is to attempt to regulate the patient's diet as though he were not to be given insulin, with, however, somewhat more liberality of diet than was permissible under the Allen régime; then, if on this definite diet the patient is unable properly to metabolize the food, insulin should be given in sufficient quantities. As a rule, many diabetics will remain sugar-free (urine) on dietary measures alone; and except in the severest cases, small doses of insulin will suffice to compensate for pancreatic insufficiency.

Of course, there is a bone of contention as to the relative amounts of fat, carbohydrate and protein to give, a consideration of which would lead us too far afield. However, some such as Sansum⁸ and Foster³³ give extremely liberal diets and use insulin in as large doses as are necessary to metabolize this excess food. Nevertheless, Joslin's reasons for attempting to use the small dose of insulin, necessitating more strict dietary control, are very convincing. He and many others believe that the proper approach is to diet the patient with a moderate undernutrition. And, as stated above, if on this diet the patient is still unable to metabolize correctly, sufficient insulin is supplied to take care of the excess carbohydrate, using relatively small doses of the hormone. "Diet is today, as it was in the Naunyn or Allen period, the bed-rock upon which all the superstructure stands, but, because of insulin, the diet of today is a much more satisfactory diet and the diabetic of today is a living and not a starving, dying diabetic."⁸

There has been, unfortunately, a great tendency among surgeons to shirk their responsibility in the management of a diabetic. While it is true that the proper management of such an individual, particularly one subjected to surgery, is an extremely difficult problem, still it is an unhealthy attitude for the surgeon to assume when he turns the patient over to his medical colleague and gives him the entire responsibility of preparing the case and giving the signal when to operate. There is nothing mysterious or incomprehensible about the management of such patients, certainly not as regards general principles. Of course, you can't treat a patient with general principles: he must have definite amounts of food and definite doses of insulin. The internist should be consulted, of course, his judgment should be given preference and he should largely be responsible for the details in the management of the patient. But the surgeon should coöperate and give intelligent attention to the patient even in the pre-operative and post-operative period. The problems which present themselves in these periods are not entirely medical, and if, the surgeon leaves the internist to wrestle with the problem alone, the best interests of the patient are at stake, for the internist in his zeal to regulate the disturbed metabolism may lose sight of the surgical conditions which must be concomitantly handled.

Still another point should be emphasized: the necessity for individualization. Human beings are not built like machines, precise and exact in every detail, and just as there are no two individuals constructed exactly alike, so are there no two who function just alike. Everywhere in medicine we

are cautioned of the need for individualization in treatment, and it certainly applies in the handling of the diabetic.

As in all surgery, there are two divisions of diabetic surgery: (1) The elective, and (2) the emergency. The elective subject, of course, offers the most ideal conditions. His problems differ little from that of the non-surgical diabetic. In this elective surgery, ample time is at hand to regulate the individual's diet and insulin dosage and to get him into the best shape possible before surgical intervention. Under these ideal conditions, the diabetic has almost equally as good chances as his non-diabetic brother, and insulin is largely responsible for this favorable outlook. In general, the management follows that of the ordinary, non-surgical diabetic, with the exception, however, that there is a more liberal use of carbohydrates and a consequent more liberal use of insulin, and an attempt is made to equilibrate the patient more rapidly than is ordinarily necessary. Children are not as frequent subjects for surgery as adults, but if they are, there is even a more liberal dosage of insulin, as even in the ordinary state of uncomplicated diabetes, insulin is used more freely than in adults, the necessity of which has been emphasized by Herold⁴⁶ and others.

The patient who is to be the subject of an elective surgical procedure is preferably admitted to the hospital several days in advance of the actual surgery; he is put to bed on a basic diet rather liberal in carbohydrates, such as approximately 1 gram protein per kilo, $1\frac{1}{2}$ to 2 grams carbohydrate per kilo and $2\frac{1}{2}$ to 3 grams fat per kilo, the latter being adjusted so as to assure a caloric intake of 20 to 25 calories per kilo, remembering that each gram of carbohydrate and protein yields 4 calories, each gram of fat, 9 calories.

If on this diet hyperglycemia or glycosuria persists, then sufficient insulin is administered to overcome it. The exact diet formulæ of Woodyat and others, so popular in the pre-insulin era, have largely been discarded. The proper handling of a diabetic is so individualistic that no general formulæ can be universally applied. It is more nearly a process of trial and error in regulating a diabetic's diet and his insulin; except that in the surgical diabetic there is less time for trial, and error is more likely to be a calamity than in the non-surgical case.

As Foster³² has said, every patient with diabetes who is operated on should be regarded as a candidate for coma, and its prevention is better than its cure. Thus the reason for a more liberal use of carbohydrate in these surgical cases is obvious, for it is in sufficient metabolism of sugars that we have our prevention or our cure of acidosis. While the possible pitfalls of depending upon the amount of glycosuria as an index for the amount of insulin required must be remembered, still, for practical purposes, if the approximate renal threshold is known from a preliminary blood-sugar determination, reliance upon the urinary "spill" is reasonably safe, if checked with blood determinations from time to time. Again, the regulation of in-

sulin is largely a trial and error proposition beginning with small doses one-half hour before meals, three times daily, and increasing the amount until the urine is normal or essentially so. Ohler⁹² has arranged a very helpful scheme for estimating the amount of insulin required, judged by the reduction of Benedict's solution by the urine. His plan is as follows:

No sugar	no insulin.
Greenish color	5 units of insulin.
Yellow-green color	10 units of insulin.
Brown color	15 units of insulin.
Red color	20 units of insulin.
Diacetic acid	20 units of insulin.

While the patient is being regulated dietetically, he should be thoroughly surveyed from a clinical and laboratory viewpoint, and finally, on the day of operation, he should receive an extra amount of glucose to combat any possible acidosis. This extra glucose may be in the form of oatmeal gruel, orange juice, *etc.*, or if there is a definite need for a larger amount of sugar, it may be given in solution, by vein. Sufficient insulin should be given concomitantly to metabolize this extra glucose, figuring about one unit of insulin for each two and one-half grams glucose given. Likewise, post-operatively, extra glucose should be given over and above that which is maintaining the patient.

The diabetic is not immune to other conditions which are only remotely related to diabetes and which are sometimes the object of elective surgery. Thus there is the question of tuberculosis in the diabetic. Ever since Richard,²⁹ in 1694, reported the occurrence of diabetes and tuberculosis in the same individual, it has presented a serious problem. While some have claimed that insulin aggravates a tuberculous condition,²⁵ by far the most eminent authorities agree that insulin has no particular deleterious effect on the tuberculous process and is greatly beneficial.^{20, 45, 58, 63} As the therapy of tuberculosis advances, more and more surgery is being advocated, such as pneumothorax, phrenic nerve surgery, thoracoplasty, *etc.* Since the advent of insulin, the tuberculous-diabetic individual need no longer be denied what benefits may accrue to his tuberculosis from surgical intervention.

A much more serious problem, however, is the management of the diabetic who must submit himself to an emergency surgical procedure. This emergency may be some complication of the diabetes, usually the result of cardiovascular degenerative changes, or an infection; or the emergency may be a condition unrelated to the diabetes, such as ruptured peptic ulcer, strangulated hernia, *etc.* If the patient is not actually in coma, it is undoubtedly best to disregard the diabetic condition, that is, for the time being, and treat the surgical condition first. Particularly in infections is it true that the surgical condition itself is frequently serving to aggravate the diabetes, and correction of this will often, in itself, serve to improve markedly the disordered metabolism. In the emergencies, diet is of no immediate concern, but it is advisable to combat acidosis and coma from the onset by the

liberal use of glucose, by mouth or vein, with sufficient insulin to assure its metabolism. Even more so than in most cases, generalizations are impossible and each case must be a law unto itself. Greater reliance must be placed upon the laboratory examinations than is usually necessary. If time permits, blood-sugar and carbon dioxide combining-power determinations are valuable guides to the patient's condition and to the therapy indicated. If time is too pressing, glucose and insulin must be given based upon the urinary findings, perhaps following such a scheme as Ohler has suggested. To a great extent the exact quantity of insulin given is empirical. If the patient's general condition warrants it, the surgical condition is first eradicated and only then is attention turned to righting the metabolic disorder.

As has been pointed out, usually in these emergencies, though not invariably by any means, the diabetes itself is of a more severe grade; and if the patient is not in coma, he is frequently on its verge. It is always an ever-present sword of Damocles. So the one essential pre-operative measure is to combat any tendency to acidosis, by the liberal usage of glucose and insulin. Here again it should be emphasized that hyperglycæmia, in itself, is relatively harmless, but not so hypoglycæmia or acidosis. The significance of this, if appreciated, is an important guide to therapy, especially in an emergency: ample glucose should be given to be certain that the acetone bodies are oxidized when insulin is added, while at the same time making sure that there is enough glucose to more than react with the insulin, so that the patient is not thrown into the dangerous hypoglycæmic state. Judged by the insulin given, it is much safer to give an excess of glucose than too little.

After the correction of the surgical ailment, particularly if it be in the nature of an infection, marked improvement in the disordered metabolism will be frequently noted, and the amount of insulin necessary to keep the urine free of diacetic acid and relatively free of sugar will be markedly less. Infections, such as purulent collections, serve in part to counteract the action of insulin, and after their drainage the amount of insulin required is usually decreased. Lawrence and McCance⁶⁸ report a case which would indicate that the inhibition of insulin action by infections and sepsis is not due directly to the sepsis or toxins, but to the accompanying febrile reaction. They likewise suggest that the need for more insulin may result from increased activity of the adrenals and thyroid, recognized antagonists of the pancreatic islets. However, Warren¹²⁴ believes that sepsis decreases the effect of insulin in maintaining a normal glycogen distribution and in this manner unfavorably influences the diabetic state. The therapy in these cases varies from hour to hour. As Joslin has emphasized, it is safer to give frequent, small doses of insulin rather than infrequent, large ones.

Too much blind faith must not be placed in insulin, trusting it to snatch our patients from the very jaws of death. Invaluable though it is, it will sometimes fail in the severest cases. So particularly in these cases of emergency, which are so often the graver forms of diabetes, the insulin must be supplemented by other measures, particularly ample quantities of fluid to

dilute and help excrete the acid substances.¹⁸ As Lemann⁷⁰ and others have emphasized, alkalis, in these severe cases, are not only useless but are actually harmful. Other than more energetic use of these auxiliary measures, and more frequent laboratory checks on the patient's condition, the post-operative handling of these cases differs not a great deal from those of the elective surgical group.

A fact which has been mentioned by a number of writers and should always be borne in mind is that a patient in diabetic coma may present a picture not unlike an acute abdomen. Abdominal pain and leucocytosis may be evidences of impending coma and it is perfectly possible to conceive that such a patient, falling into careless hands, might be mistakenly laparotomized. It has been suggested, though not proven, that the pain and leucocytosis may be due to a pancreatitis. Saunders¹⁰⁵ found in a series of eighty diabetic cases that this difficulty in diagnosis arose in two instances, but he doubts that a simple diabetic coma can, in itself, give the symptomatology of an acute abdomen.

As we have already intimated, numerous claims for the therapeutic efficacy of insulin in various and sundry conditions have been made. The value of this hormone in many of these conditions is questionable, to say the least. Almost the whole gamut of medical and surgical diseases has been experimented with in attempting to apply insulin therapeutically, including mental disorders, Parkinson's disease, cyclothymia, dermatoses, diphtheria,⁹ *etc.* However, we will attempt here to consider only the more important applications, particularly surgical conditions.

One of the most frequent conditions seen, especially post-operatively, is acidosis, non-diabetic in origin. For a number of years, the great value of glucose in the handling of this condition has been appreciated, and after the introduction of insulin, the analogy seemed obvious: Insulin and glucose is specific in diabetic acidosis, so why not in its near-relative, non-diabetic acidosis? But this is a question about which no definite agreement has been reached. That is, not only in acidosis, but in any condition where glucose is indicated, such as vomiting of pregnancy, liver disease, *etc.*, there has been a question as to whether or not insulin should be given routinely. Titus¹²¹ and Thalhimer¹¹⁰ have been two of the staunchest leaders of opposite schools, the former not believing insulin is indicated in non-diabetic conditions, the latter claiming that whenever glucose is given, enough insulin should be used to help metabolize it. As is usually the case, they are probably both right, and the need for individualization of cases is again evident; no one rule will cover all cases even of the same general class.

Those who believe that insulin should be given with glucose feel that the glucose causes a "strain," as it were, on the island tissue and may precipitate a diabetic condition, particularly if there is any latent deficiency of insulin. While this possible etiological factor has long been popular in diabetic discourses, there is no definite clinical proof that a normal, or even a diseased pancreas can be "strained" to such a point that the damage is irreparable, with an

ensuing diabetic state. In fact, it is well known that if moderate doses of glucose be administered, not only is sufficient insulin liberated by the pancreatic tissue, but an excess is produced. If, in addition, exogenous insulin is administered, there is a very real danger of producing a hypoglycæmic state. So individualize. If urinalysis shows a constant "spill" after glucose administration, indicating hypoinsulinism, then moderate doses of insulin should be given with the next amount of glucose to aid in its combustion. It need hardly be stated that glucose should never be administered without a preliminary urinalysis, preferably a blood-sugar determination.

However, in cases of increased intracranial pressure, such as follows head injuries, unless the patient is actually diabetic, the administration of insulin is contraindicated: it is the hypertonicity of the blood produced by the glucose that is of benefit in reducing intracranial pressure; if insulin is given the glucose is so rapidly utilized that its value is extremely doubtful.

As for the routes of glucose administration, unquestionably the intravenous path is the most reliable. Rectal drips are quite popular with many, but there is considerable question as to whether there is very much absorbed in this manner.^{81, 82, 98}

Ever since insulin has been available clinically it has been used, apparently with good results, as a local applicant for ulcers, in non-diabetic as well as diabetic individuals. While originally it was believed that the local application of this hormone caused an improvement in the local tissue metabolism and hence a clinical improvement, the experiments of Nathan and Munk⁹⁰ have rather conclusively shown that any improvement is due to the acidity of the preparation, not to the insulin *per se*.

Disorders of menstruation seem rather a remote subject from that of insulin, yet rather encouraging results have been obtained in the treatment of some of these disorders with insulin. Those menstrual disturbances, whether excessive bleeding or amenorrhœa, which arise not from any organic change but rather from some ovarian dysfunction, respond very nicely to small, repeated doses of insulin. This substance apparently has a regulatory action on ovarian function, as has been particularly pointed out by several foreign investigators.^{23, 47, 123}

The question of malnutrition and the underweight individual while not strictly a surgical problem is of enough importance to warrant a brief consideration. The surgeon quite frequently has his problems of undernutrition and anorexia to deal with, and they are at times quite perplexing. Fonseca³⁰ has suggested that most cases of obesity are due to hyperinsulinism. He believes that the reason so many fat individuals become diabetic is that prolonged hyperinsulinism finally exhausts the island tissue.²¹ The German Falta is credited by Metz⁸³ with having, in 1925, introduced the use of insulin in malnutrition. There have been numbers of reports to the effect that small doses of insulin do stimulate the appetite and cause definite increase in weight, not only in otherwise normal individuals but also in patients suffering with malignancies, tuberculosis, *etc.*^{5, 16, 30, 91, 111} Presumably its

action is through the production of a hypoglycæmia, which in turn stimulates the appetite and increases the amount of food intake and accelerates its rate of utilization.

Insulin apparently has a definite effect on the gastro-intestinal tract, not only upon its motility but also upon its secretions, particularly those of the stomach. While it does seemingly definitely increase gastric motility,^{14, 112} its more important clinical application is its stimulating effect on the gastric secretions, both HCl and the ferments. This stimulatory effect on these secretions, with a consequent improvement in digestion, may be a factor in the benefits in malnutrition which follow the use of this substance. In the diabetic, this increased acidity, *etc.*, is probably beneficial, as Rabinowitch and his co-workers,¹⁰⁰ from a careful study of 100 cases, have concluded that, as a rule, gastric acidity is decreased in diabetes mellitus. Because of this increase in acidity caused by insulin injection, it is questionable whether it is advisable to use this hormone in cases of gastric ulcer; yet paradoxically, cases have been reported where insulin administration has seemed to quiet the gastric pain¹¹³ or actually cause the ulcer to disappear.³⁹ Still another danger, at least a theoretical one, of using insulin in ulcer patients, is that the pylorospasm which almost invariably accompanies such a condition may cause gastric retention of food, with insufficient carbohydrate absorption to buffer the insulin given.⁵²

Insulin probably causes the increased gastric acidity by means of a hypoglycæmia⁷⁴ and not because of the protein present in the preparation. It will not, however, cause increased gastric secretion in a condition of true achylia gastrica and it has been recommended⁸⁴ as a means of differentiating this condition from simple anacidity, just as histamine is now commonly used. In normal individuals, six to eight units of insulin will cause an increase in gastric acidity reaching its maximum in seventy-five to ninety minutes.

Such a powerful substance as insulin is not without its dangers and its untoward effects. Though rare, death apparently attributable solely to the effect of the insulin has been reported. Certainly the most frequent reaction noted, and probably the most serious, is that of hypoglycæmia. Hypoglycæmic reactions occur frequently in the treatment of ordinary diabetes, particularly in children. Often it is mild, is quickly recognized and easily combated by the ingestion of orange juice or some other form of glucose. It is important to differentiate between the hypoglycæmic state and one of diabetic coma, something which at times is not easy. The treatment, obviously is diametrically opposite in the two states. The clinical picture of the two may be somewhat similar, though differentiation is usually possible. The history usually permits of ready distinction; urinalysis or blood-sugar determination will permit of differentiation if there be any question. Several minor differential points also have been noted. In coma, as we have seen, a leucocytosis is usually present; in insulin shock there is frequently a low white count, though Stockinger and Kober claim that insulin may produce a

leucocytosis.¹¹⁶ A helpful differential point not commonly known is that in insulin shock (hypoglycæmia) a Babinski plantar reflex is usually elicitable.^{3, 10}

Glucose is specific in counteracting the insulin reaction, particularly if given by vein; adrenalin, probably through increasing hepatic glycogenolysis, will throw more endogenous glucose into the blood-stream to buffer the insulin, and has often proven a life-saving procedure; however, continuous adrenalin administration may interfere with proper glucose combustion.²² Caffeine has been claimed by Popper and Jahoda⁹⁷ to have a specific counter-acting effect in insulin poisoning. Incidentally, these authors believe that the reaction seen in insulin intoxication is not solely due to variations in the blood-sugar content. Imerman⁵¹ has used glucose intracardially in grave forms of insulin reaction, with success.

A great deal has been written regarding the relationship between insulin and the heart and circulation in general.^{26, 43, 73, 85, 86, 122} Many have noted deleterious circulatory effects from excessive insulin dosage, but in all probability any untoward effects have been the result of hypoglycæmia, which will undoubtedly embarrass an already diseased heart. However, Parsonnet and Hyman⁹³ report seven cases in which insulin precipitated a severe anginal attack, one of them ending fatally, and yet in none of which was there a demonstrable hypoglycæmia present. If careful insulin dosage is used, there should be no fear of harmful circulatory developments.

A rather unusual condition which is sometimes seen, is that of an individual refractory or resistant to insulin.^{6, 35, 48, 61, 65} Schmidt,¹⁰⁸ we have seen, believes that these cases result from inactivation of the insulin by the tissues at the site of injection. Though such an insulin-refractory case is seen at times in an unquestioned case of diabetes mellitus, many authors believe that such a case is either an example of renal diabetes or that it is some new form of diabetes, non-pancreatic in origin, the exact nature of which has not been determined.²⁷ Such an extra-insular condition has been reported following epidemic encephalitis,⁴⁴ but apparently a non-pancreatic form of diabetes mellitus exists for which no etiological factor can be found. Zeckwer, of the University of Pennsylvania, has reported some interesting observations and experiments in rabbits which indicate that insulin resistance may be the result of abnormal action of the sympathetic system, possibly through the intermediation of the thyroid. The thyroid, adrenal and pituitary glands are generally accepted as being antagonistic to insulin in their action.

A more frequent, and sometimes more alarming condition, is that of hypersusceptibility to insulin in which, following administration of this hormone, allergic symptoms develop.^{40, 53, 101, 118, 130} Williams¹³⁰ differentiates the hyperinsulinism reaction from allergic reaction; the allergic may be either local or systemic, and apparently is due to the protein content of the preparation. Herold⁴⁶ has pointed out how severe these general reactions may be, and that it is sometimes necessary to change the insulin preparation in order to obtain one to which the patient is not sensitized.

Numerous and sundry other untoward effects of insulin have been reported such as hæmaturia,⁶⁶ insulin lipodystrophy⁹ (which is a localized atrophy of the subcutaneous tissues at the site of injection), retinal detachment,⁷⁸ anuria,¹²⁶ *etc.*, *ad infinitum*. In many instances it is more than questionable as to whether or not some of the untoward results that have been noted after insulin therapy are not entirely coincidental.

Insulin does have an effect on water metabolism, one of dehydration. Therefore, it is reasonable to suppose that it may have undesirable effects if used promiscuously in post-operative cases, which are notoriously dehydrated.¹

No discussion of the relationships between insulin and surgery would be complete without mention of the clinical condition of spontaneous pancreatic hypoglycæmia, which has been variously called "hyperinsulinism," "dysinsulinism," "insulinosis" and "dysinsulinosis." Gammon and Tenery³⁶ have presented an interesting discussion of spontaneous hyperglycæmia, and have attempted an etiological classification. It is largely those cases resulting from abnormal pancreatic activity which have, thus far, been of any particular surgical interest.

Hyperinsulinism was first reported clinically in 1924, by Seale Harris.⁴¹ Such overproduction of insulin may result either from hypertrophy or hyperfunction of the islets, or from a benign or malignant tumor of them. Clinically, hyperinsulinism manifests itself in a number of ways, usually resembling insulin shock: weakness, fatigue, nervousness, tremor, hunger, visual or gastro-intestinal disturbances or epileptoid phenomena are the symptoms usually present.

The surgical importance of this syndrome is that a number of cases have been completely cured, either by a partial pancreatectomy, as first performed by the Finneys,²⁸ or by the surgical removal of a pancreatic adenoma^{1, 13, 50, 131} and because the symptoms of hyperinsulinism have been noted in carcinoma of the pancreas^{120, 129} and in carcinoma of the liver^{24, 89} as well as in simple hypertrophy of the islands of Langerhans.⁹⁶ There is every reason to suppose that further clinical and laboratory observations will differentiate an ever-increasing number of conditions, which are at present obscure in nature, and prove them to be due to dysfunction of the insulin-producing mechanism, and which may be amenable to surgical therapy.

BIBLIOGRAPHY

- ¹ Allan, F. N.: Hyperinsulinism. *Arch. Int. Med.*, vol. xlv, p. 65, 1929.
- ² Allan, F. N., and Vanzant, F. R.: Renal Glycosuria, with Ketosis, during Surgical Complications. *Am. Jour. Med. Sc.*, vol. clxxx, p. 670, 1930.
- ³ Andersen, B.: Om Insulinforgiftning og Babinskis Taafaenomen. *Ugeskrift f. Laeger*, vol. xciii, p. 5, January, 1931.
- ⁴ Andrews, E., and Reuterskiold, K.: Dangers in Post-operative Use of Insulin. *Surg., Gynec., and Obs.*, vol. xlvii, p. 665, 1928.
- ⁵ Appel, K. E., Farr, C. B., and Marshall, H. K.: Insulin in Undernourished Psychotic Patients. *Jour. A. M. A.*, vol. xc, p. 1988, 1928.

- ⁶ Basch, E.: Ueber einen insulinrefraktären Fall von Diabetes mellitus. *Klin. Wchnschr.*, vol. iii, p. 1861, 1924.
- ⁷ Bazin, A. T.: The Surgical Problems Presented by the Diabetic. *Canadian M. Ass. J.*, vol. xxiii, p. 146, 1930.
- ⁸ Beckman, H.: Treatment in General Practice. W. B. Saunders, Pub., 1930.
- ⁹ Boller, R.: Behandlung der Insulin-Lipodystrophie. *Klin. Wchnschr.*, vol. ix, p. 2433, 1930.
- ¹⁰ Bond, H. P., and Hart, P. M. D'A.: Diagnostic Value of Plantar Response in Insulin Coma. *Brit. Med. Jour.*, vol. i, p. 895, 1929.
- ¹¹ Budapest Letter. *Jour. A. M. A.*, vol. xcvi, p. 1329, April 18, 1931.
- ¹² Cammidge, P. J.: Prostatectomy in Diabetics. *Brit. Jour. Urol.*, vol. i, p. 258, 1929.
- ¹³ Carr, A. D., Parker, R., Grove, E., Fisher, A. O., and Larimore, J. W.: Hyperinsulinism from B-cell Adenoma of Pancreas. *Jour. A. M. A.*, vol. xcvi, p. 1363, April 25, 1931.
- ¹⁴ Cascao de Ancaes, J. H.: Insulin and Magenfunktion. *Arch. f. Verdauungskr.*, vol. xlii, p. 377, 1928.
- ¹⁵ Cayrel, M.: La syndrome d'ipoglicemia. *Riforma med.*, vol. xli, 493, 1925.
- ¹⁶ Ceccarelli, D.: La terapia insulinica negli stati di dimagrimento consecutivi a colecistite calcolosa. *Policlinico (sez. prat.)*, vol. xxxvii, p. 1665, 1930.
- ¹⁷ Chabanier, H., Lobo-Onell, C., and Lelu, E.: Resultats obtenus à l'aide d'une suspension huileuse d'insuline dans l'attaque des diabètes graves. *Presse méd.*, vol. xxxix, p. 219, February 14, 1931.
- ¹⁸ Coburn, A. F.: Diabetic Ketosis and Functional Renal Insufficiency. *Am. Jour. Med. Sc.*, vol. clxxx, p. 178, 1930.
- ¹⁹ Colley, B. L.: The Surgical Complications of Diabetes. *Idem.*, vol. clxxvi, p. 491, 1928.
- ²⁰ Collip: Proc. Soc. Exp. Biol. and Med., vol. xx, p. 321, 1923. Quoted by Joslin.
- ²¹ Columba, D.: L'insulmemia nell'obesità e nella magrezza. *Policlinico (Sez. prat.)*, vol. xxxviii, p. 219, February 16, 1930.
- ²² Colwell, A. R.: Suppression of Glucose Combustion by Epinephrine Administration. *Endocrinology*, vol. xv, p. 25, January-February, 1931.
- ²³ Cotte, G.: Traitement des menorrhagies d'origine ovarienne par l'insuline. *Presse méd.*, vol. xxxvi, p. 181, 1928.
- ²⁴ Crawford, W. H.: Hypoglycemia with Coma in a Case of Primary Carcinoma of the Liver. *Am. Jour. Med. Sc.*, vol. clxxxi, p. 496, April, 1931.
- ²⁵ Dünner, L., and Dohrn, M.: Klinische und experimentelle Untersuchungen über die Wirkung des Insulins bei Tuberkulose. *München Med. Wchnschr.*, vol. lxxv, p. 974, 1928.
- ²⁶ Dwörkin, S.: Insulin and Heart Rate after Sympathectomy and Vagotomy. *Am. Jour. Physiol.*, vol. cxvi, p. 311, February, 1931.
- ²⁷ Falta, W., and Boller, R.: Insulärer und Insulinresistenter diabetes. *Klin. Wchnschr.*, vol. x, p. 438, March 7, 1931.
- ²⁸ Finney, J. M. T., and Finney, J. M. T., Jr.: Resection of the Pancreas, *ANNALS OF SURGERY*, vol. lxxxviii, p. 584, 1928.
- ²⁹ Fitz, R.: The Problem of Pulmonary Tuberculosis in Patients with Diabetes. *Am. Jour. Med. Sc.*, vol. clxxx, p. 192, 1930.
- ³⁰ Fonseca, F.: Margerkeit und insulin. *Arch. f. Verdauungskr.*, vol. xlii, p. 362, 1928.
- ³¹ Foord, A. G., and Bowen, B. D.: Acute Interstitial Pancreatitis in 2 Cases of Diabetic Coma. *Am. Jour. Med. Sc.*, vol. clxxx, p. 676, 1930.
- ³² Foster, N. B.: Surgical Aspects of Diabetes. *Jour. A. M. A.*, vol. lxxxiv, p. 572, 1925.
- ³³ *Ibid.*: Insulin: Its Use and Misuse. *Jour. A. M. A.*, vol. xciv, p. 1971, 1930.
- ³⁴ *Ibid.*: Foods and Diets in Diabetes. *Jour. A. M. A.*, vol. xciv, p. 1974, 1930.
- ³⁵ Frank, E.: Ueber Insulinresistenten Diabetes. *Klin. Wchnschr.*, vol. v, p. 688, 1926.

- ³⁶ Gammon, G. D., and Tenery, W. C.: Hypoglycemia. *Arch. Int. Med.*, vol. xlvii, p. 829, June, 1931.
- ³⁷ Gilchrist, A. R.: Care of Surgical Diabetic. *Edinburgh Med. Jour.*, vol. xxxviii, p. 30, January, 1931.
- ³⁸ Gottschalk, A.: Zur Frage der Insulinverteilung und Blutzuckerbestimmung bei der Diabetesbehandlung. *München Med. Wchnschr.*, vol. xxvii, p. 793, 1930.
- ³⁹ Goyena, J. R.: *Úlcera de la curvadura menor del estómago curada con insulina. Semana méd.*, vol. ii, p. 1325, 1927.
- ⁴⁰ Hajek, Joe.: Local Insulin Reaction. *Jour. A. M. A.*, vol. xcvi, p. 193, January 17, 1931.
- ⁴¹ Harris, Seale: Hyperinsulinism and Dysinsulinism. *Jour. A. M. A.*, vol. lxxxiii, p. 729, 1924.
- ⁴² Hauser, E. T., and Foster, N. B.: Surgical Aspects of Diabetes. *Nelson's Loose Leaf Surgery*, vol. ii, p. 263.
- ⁴³ Haynal, E., Vidovszky, L., and Györgi, G.: Elektrokardiographische Untersuchungen über insulinwirkung auf der Herz, Insulin und geschädigter Herzmuskel. *Klin. Wchnschr.*, vol. vii, p. 1543, 1928.
- ⁴⁴ Held, I. W., Goldbloom, A. A., and Chasnoff, J.: Extra-insular (Central) Glycosuria with Hyperglycemia Following Epidemic Encephalitis. *Arch. Int. Med.*, vol. iv, p. 897, February, 1931.
- ⁴⁵ Herold, A. A.: Modern Aspects of Diabetes. *Tri-state Medical Jour.*, vol. iii, p. 446, 1930.
- ⁴⁶ *Ibid.*: Juvenile Diabetes. *N. O. Med. and Surg. Jour.*, vol. lxxxiii, p. 766, May, 1931.
- ⁴⁷ Hofman-Bang, A.: Hat das Insulin Einfluss auf die innere Sekretion de Ovarian? *Zentralbl. f. Gynäk.*, vol. liv, p. 1223, 1930.
- ⁴⁸ Högler, F., and Häusler, H.: Untersuchungen bei einem Fall von Insulinrefraktärem Diabetes, *Klin. Wchnschr.*, vol. vi, p. 541, 1927.
- ⁴⁹ Holzer, H., and Klein, O.: Zur Aenderung der Stoffwechsellage schwerer Diabetesfälle nach kurz dauernder Behandlung mit hohen Insulindosen. *Deutsche Arch. f. klin. Med.*, vol. cliii, p. 129, 1926.
- ⁵⁰ Howland, G., Campbell, W. R., Maltby, E. J., and Robinson, W. L.: Dysinsulinism. *Jour. A. M. A.*, vol. xciii, p. 674, 1929.
- ⁵¹ Imerman, Stanley W.: *Jour. A. M. A.*, vol. lxxxix, p. 1778, 1927. Quoted by Sajous.
- ⁵² Jankelson, I. R., and Rudy, A.: The Simultaneous Occurrence of Peptic Ulcer with Diabetes or Glycosuria. *Am. Jour. Med. Sc.*, vol. clxxxi, p. 356, March, 1931.
- ⁵³ Jeanneret, R.: Une application pratique de la méthode de désensibilisation par les cuti-réactions répétées. *Uticaire à l'insuline. Rev. méd. de la Suisse Rom.*, vol. xlix, p. 99, 1929.
- ⁵⁴ Jobson, A. C.: Surgery in the Diabetic. *Jour. Fla. Med. Ass.*, vol. xvi, p. 20, 1929.
- ⁵⁵ John, H. J.: Time Relation of the Fall of Blood Sugar with Insulin. *Jour. Metab. Research*, vol. iv, p. 121, 1923.
- ⁵⁶ *Ibid.*: Variations in the Blood-sugar Content Following the Administration of Insulin. *Jour. Lab. and Clin. Med.*, vol. xi, p. 548, 1926.
- ⁵⁷ *Ibid.*: Hyperinsulinism. *Surg., Gynec., Obs.*, vol. xlv, p. 190, 1927.
- ⁵⁸ Joslin, E. P.: *The Treatment of Diabetes Mellitus. Fourth Edition.* Lea and Febiger, Pub., 1928.
- ⁵⁹ *Ibid.*: The Diabetic Patient and His Condition Preparatory to Anesthesia. *Anesth. and Analges.*, vol. viii, p. 61, 1929.
- ⁶⁰ Judd, E. S., Wilder, R. M., and Adams, S. F.: Surgery in the Presence of Diabetes. *Jour. A. M. A.*, vol. lxxxvi, p. 1107, 1926.
- ⁶¹ Keller, F.: Ueber einen Fall von insulinrefraktärem Diabetes Mellitus. *Wien, klin. Wchnschr.*, vol. xxxix, p. 1396, 1926.
- ⁶² Kroner, R.: Erfahrungen über die Methodik des Blutzucker-Tagesprofils beim Diabetiker. *Arch. f. Verdauungskr.*, vol. xlviii, p. 346, 1930.

INSULIN AND SURGERY

- ⁶³ Labbé, M., Boulin, R., and Justin-Besançon: Evolution de la tuberculose pulmonaire des diabétiques graves traites par la collapsothérapie bilatérale et l'insuline. Bull. et mém. Soc. méd. d. hôp. de Par., vol. liv, p. 1781, 1930.
- ⁶⁴ Labbé, M.: L'artérite diabétique. Presse méd., vol. xxxix, p. 257, 1931.
- ⁶⁵ *Ibid.*: Ueber Insulinresistenten Diabetes. Rev. Bel. d. Sc. Méd., vol. iii, p. 465, May, 1931.
- ⁶⁶ Lawrence, H., and Hollins, A. S.: Two Cases of Hematuria Caused by Insulin Treatment. Brit. Med. Jour., vol. i, p. 977, 1928.
- ⁶⁷ Lawrence, R. D.: Post-operative Acidosis. Proc. Roy. Soc. Med., vol. xxii, p. 747, 1929.
- ⁶⁸ Lawrence, R. D., and McCance, R. A.: Infections and Insulin Action; Observations on Unusual Case. Brit. Med. Jour., vol. i, p. 749, May 2, 1931.
- ⁶⁹ Legrand, R.: L'emploi de l'insuline par la voie percutanée. Presse méd., vol. xxxvii, p. 42, 1929.
- ⁷⁰ Lemann, I. I.: The Futility of Alkali Treatment in Diabetic Coma. Am. Jour. Med. Sc., vol. clxxx, p. 266, 1930.
- ⁷¹ Leyton, O.: The Administration of Insulin in Suspension. Clin. Med. and Surg., vol. xxxiv, p. 299, 1929; Lancet, vol. i, p. 576, 1929.
- ⁷² Livierato, P. E.: A proposito dell' insulina. Riforma med., Napoli, vol. xl, p. 30, 1924.
- ⁷³ Loeper, M., Lemaire, A., and Degos, R.: L'insuline dans la nutrition du coeur des cardiaques. Presse méd., vol. xxxviii, p. 1361, 1930.
- ⁷⁴ Lueders, C. W., and Scherer, L. R.: Gastric Acidity in Relation to Biliary Tract Disease. Am. Jour. Surg., N. S., vol. xi, p. 280, February, 1931.
- ⁷⁵ Maes, Urban: Preoperative Preparation. N. O. Med. and Surg. Jour., vol. xxxiii, p. 14, 1930.
- ⁷⁶ Mallory, W. J., and Roe, J. H.: A Problem in Insulin Therapy. Jour. Lab. and Clin. Med., vol. xi, p. 560, 1926.
- ⁷⁷ Marriott, W. M.: Recent Advances in Chemistry in Relation to Modern Medical Practice, p. 54, C. V. Mosby, Pub., 1928.
- ⁷⁸ McBean, G. M.: Retinal Detachment Following Administration of Insulin. Am. Jour. Ophth., vol. xviii, p. 825, 1929.
- ⁷⁹ McCrudden, R. H., and Sargent, C. S.: Hypoglycemia and Progressive muscular dystrophy. Arch. Int. Med., vol. xvii, p. 465, 1916.
- ⁸⁰ McKittrick, L. S., and Pratt, T. C.: The Operative Treatment of Lesions of the Lower Extremities in Diabetes Mellitus. Arch. Surg., vol. xxi, p. 555, 1930.
- ⁸¹ McNealy, R. W., and Willems, J. D.: Value of Glucose Administration per rectum. Surg., Gynec., and Obs., vol. xlix, p. 794, 1930.
- ⁸² *Ibid.*: Absorption of Dextrose from Colon. Arch. Surg., vol. xxii, p. 649, April, 1931.
- ⁸³ Metz, R. D.: Insulin in Malnutrition. Jour. A. M. A., vol. xcvi, p. 1456, May 2, 1931.
- ⁸⁴ Meyer, P. F.: Über die Wirkung des Insulins auf die Magensekretion. Klin. Wchnschr., vol. ix, p. 1578, 1930.
- ⁸⁵ Middleton, W. S., and Oatway, W. H.: Insulin Shock and the Myocardium. Am. Jour. Med. Sc., vol. clxxx, p. 39, January, 1931.
- ⁸⁶ Modern, F. S.: Chronic Heart Pain Due to Prolonged Hypoglycemia. Jour. A. M. A., vol. xcvi, p. 357, January 31, 1931.
- ⁸⁷ Muller, G. P.: Diabetes in Its Relation to Surgery. Minn. Med., vol. xii, p. 573, 1929.
- ⁸⁸ Müller, Wiener, and Wiener: Arch. Int. Med., vol. xxxvii, p. 512, 1926. Quoted by Joslin.
- ⁸⁹ Nadler, W. H., and Wolfer, J. A.: Hepatogenic Hypoglycemia Associated with Primary Liver Cell Carcinoma. Arch. Int. Med., vol. xlv, p. 700, 1929.
- ⁹⁰ Nathan, E., and Munk, A.: Über de Einfluss lokaler Insulinbehandlung auf Ulcerationen, zugleich ein Beitrag zur Kenntnis lokaler Säuerwirkungen. Klin. Wchnschr., vol. vi, p. 1747, 1927.

- ⁹¹ Nichol, E. E.: Use of Insulin in Fattening Lean Individuals. Jour. Fla. Med. Assn., vol. xvi, p. 29, 1929.
- ⁹² Ohler, W. R.: The Care of the Surgical Diabetic. New Eng. Jour. Med., vol. cci, p. 259, 1929.
- ⁹³ Parsonnet, A. E., and Hyman, A. S.: Insulin Angina. Ann. Int. Med., vol. iv, p. 1247, April, 1931.
- ⁹⁴ Pemberton, H. S.: The Use of Insulin in Operations on the Diabetic. Lancet, vol. ii, p. 647, 1924.
- ⁹⁵ *Ibid.*: Hypoglycemia, with Notes on 2 Cases. Brit. Med. Jour., vol. i, p. 1004, 1925.
- ⁹⁶ Phillips, A. W.: Hypoglycemia Associated with Hypertrophy of Islands of Langerhans. Jour. A. M. A., vol. xcvi, p. 1195, April 11, 1931.
- ⁹⁷ Popper, L., and Jahoda, S.: Coffeinwirkung bei hypoglykämischen Zuständen. Klin. Wchnschr., vol. ix, p. 1585, 1930.
- ⁹⁸ Pressmann, J. J.: The Absorption of Glucose per Rectum. Am. Jour. Med. Sc., vol. clxxix, p. 521, 1930.
- ⁹⁹ Pribram, E.: Chronic Glycopenia. Jour. A. M. A., vol. xc, p. 2001, 1928.
- ¹⁰⁰ Rabinowitch, I. M., Fowler, A. F., and Watson, B. A.: Gastric Acidity in Diabetes Mellitus. Arch. Int. Med., vol. xlvii, p. 384, March, 1931.
- ¹⁰¹ Raynand, M., and Lacroix, A.: Un cas d'anaphylaxie à l'insuline; essai de pathogénie des oedemes insulinien. Bull. et mém. Soc. méd. d. hôp. de Par., vol. xlix, p. 831, 1925.
- ¹⁰² Root, H. F.: Diabetic Gangrene; Medical Treatment and Prophylaxis. Arch. Surg., vol. xxii, p. 179, February, 1931.
- ¹⁰³ Sacharoff, G. P., and Danenkoff, J. S.: L'action paradoxale de l'insuline. Rev. franç. d'endocrinol., vol. iv, p. 416, 1926.
- ¹⁰⁴ Sajous's Analytic Cyclopedic of Practical Medicine, vol. x, 10th edition.
- ¹⁰⁵ Saunder's, E. W.: Diabetes in Relation to Surgery. ANNALS OF SURGERY, vol. xciv, p. 161, August, 1931.
- ¹⁰⁶ Scherer, L. R.: The Influence of Surgery on Diabetes Mellitus. Proc. Staff Mayo Clinic, vol. vi, p. 19, January 14, 1931.
- ¹⁰⁷ Schmidt, A. A.: Über den Mechanismus der Insulinwirkung. Arch. f. exper. Path. u. Pharmacol., vol. cliii, p. 79, 1930.
- ¹⁰⁸ *Ibid.*: Über Inaktivierung des Insulins. Klin. Wchnschr., vol. ix, p. 1021, 1930.
- ¹⁰⁹ Schmidt, E. G.: Terminal Hypoglycemia. Arch. Int. Med., vol. xlvii, p. 128, January, 1931.
- ¹¹⁰ Sherrill, J. G.: The Diabetic As a Surgical Risk. Anesth. and Anal., vol. vii, p. 382, 1928.
- ¹¹¹ Short, J. J.: Increasing Weight with Insulin. Jour. Lab. and Clin. Med., vol. xiv, p. 330, 1929.
- ¹¹² Simici, D., Guirea, G., and Dimitriu, C.: L'action de l'insuline sur la motilité et l'évacuation de l'estomac à l'état normal et pathologique. Arch. a. mal. a. l'app. digestif., vol. xvii, p. 17, 1927.
- ¹¹³ Simnitzky, S. S.: Das Insulin in der Therapie der peptischen Magengeschwüre. Wien. klin. Wchnschr., vol. xl, p. 1635, 1929.
- ¹¹⁴ Starr, P., and Fitz, R.: The Excretion of Organic Acids in the Urine of Patients with Diabetes Mellitus. Arch. Int. Med., vol. xxxiii, p. 97, 1924.
- ¹¹⁵ St. Lorant, I.: Zur Frage der Ursache des Coma diabeticum. Klin. Wchnschr., vol. v, p. 216, 1926.
- ¹¹⁶ Stockinger, W., and Kober, K.: Über die Insulinreaktion der Leukocyten des Blutes. Klin. Wchnschr. vol. x, p. 389, February 28, 1931.
- ¹¹⁷ Strauch, C. B.: Repository Injections. Jour. A. M. A., vol. xcii, p. 1177, 1929.
- ¹¹⁸ Sturtevant, Mills: Local Anaphylaxis Following Injection of Insulin. Jour. A. M. A., vol. lxxxii, p. 964, 1924.

INSULIN AND SURGERY

- ¹¹⁸ Thalhimer, W.: Insulin Treatment of Post-operative (Non-diabetic) Acidosis. Jour. A. M. A., vol. lxxxi, p. 383, 1923.
- ¹²⁰ Thalhimer, W., and Murphy, F. D.: Carcinoma of the Islands of the Pancreas. Jour. A. M. A., vol. xci, p. 89, 1928.
- ¹²¹ Titus, Paul: The Pre-Operative and Post-operative Use of Dextrose. Am. Jour. Surg., N. S., vol. viii, p. 1196, 1930.
- ¹²² Turner, K. B.: Insulin Shock As the Cause of Cardiac Pain. Am. Heart Jour., vol. v, p. 571, 1930.
- ¹²³ Vogt, E.: Ovarialzyklus und Insulinwirkung. Zentralbl. f. Gynäk., vol. li, p. 3034, 1927.
- ¹²⁴ Warren, S.: The Effect of Insulin on Pathological Glycogen Deposits in Diabetes Mellitus. Am. Jour. Med. Sc., vol. clxxix, p. 482, 1930.
- ¹²⁵ Wassermeyer, H., and Schäfer, A.: Über die endonasale Applikation des Insuline. Klin. Wchnschr., vol. viii, p. 210, 1929.
- ¹²⁶ Wendt, L., and Peck, F.: Diabetes Mellitus; a Review of 1073 Cases. Am. Jour. Med. Sc., vol. clxxxi, p. 52, January, 1931.
- ¹²⁷ White, W. C.: Diabetes in Surgery. N. Y. State Jour. Med., vol. xxviii, p. 428, 1928.
- ¹²⁸ Wiechmann, E.: Zur Permeabilitätstheorie des Diabetes mellitus. Deutsches Arch. f. klin. Med., vol. cl, p. 186, 1926.
- ¹²⁹ Wilder, R. M., Allan, F. N., Power, M. H., and Robertson, H. E.: Carcinoma of the Islands of the Pancreas. Jour. A. M. A., vol. lxxxix, p. 348, 1927.
- ¹³⁰ Williams, J. R.: Allergic Insulin Reactions. Jour. A. M. A., vol. xciv, p. 1112, 1930.
- ¹³¹ Womack, N. A., Gnagi, W. B., and Graham, E. A.: Adenoma of the Islands of Langerhans with Hypoglycemia. Jour. A. M. A., vol. xcvi, p. 831, September 19, 1931.

ON THE MORTALITY RESULTING FROM SURGICAL TREATMENT OF CHRONIC GALL-BLADDER DISEASE IN DIABETES MELLITUS

BY ISRAEL M. RABINOWITCH, M.D.

OF MONTREAL, CANADA

FROM THE SERVICES OF DRS. A. T. BAZIN, AND E. M. EBERTS AND THE DEPARTMENT OF METABOLISM OF THE MONTREAL GENERAL HOSPITAL

It is generally recognized that disease of the gall-bladder is very common amongst diabetics. Autopsy records indicate incidences of 10 per cent. or more among non-diabetics, but high values such as have been found in diabetes have never been recorded. The incidence among adults in our clinic for diabetes is about 25 per cent. This differs very little from the experience of other large clinics. With the introduction of newer and more exact methods of clinical examination (X-ray visualization of the gall-bladder with the aid of dye, etc.) the recognized incidence of gall-bladder disease in general is changing (increasing), but the difference between diabetic and non-diabetic individuals is still marked.

When diabetes and disease of the gall-bladder are found in the same individual, the consensus of opinion is that the relationship, at least in the majority of cases, is causal and not accidental. This view is based upon a variety of data, namely: (*a*) the above-mentioned difference in incidence, (*b*) differences between average ages at the onset of the two diseases, (*c*) clinical studies, (*d*) metabolic findings, and (*e*) statistical analyses. The literature on this subject is too well known to require reference to it in detail.

With this combination of conditions, the diabetes is generally attributed to pancreatitis caused by the biliary infection. It is regarded as a true pancreatic diabetes and somewhat analogous to that produced experimentally in partially depancreatized dogs.

Because of the above views, surgical treatment of chronic infections of the gall-bladder is now recommended not only in diabetes to control the disease when active, but also in potential diabetes to prevent its development. Results of such treatment are encouraging; in diabetes, in the majority of cases, carbohydrate tolerance is improved; in non-insulin cases the diets may be made much more attractive and in insulin-treated subjects the amount of this drug may not only be reduced, but its use may, at times, be discontinued entirely. A recent report from this hospital clearly indicates improvement of carbohydrate tolerance in "potential" diabetes.¹ (It may here be observed that, in a number of cases, the relationship between gall-bladder disease and diabetes may not be causal but accidental. To this fact is largely attributed the failure at times to observe improvement of carbohydrate tolerance following such operation.)

In spite of the possible satisfactory results from surgical treatment, the

advice to the patient is by no means a simple matter. For example, a not unimportant consideration is whether the risk from the operation may not be greater than from the diabetes *per se*. Factors which favor operation are not only the probability of preventing progressive diabetes, but the probability of improving the existing condition. Aside from diabetes and apropos of the gall-bladder *per se*, there is the elimination of a "focal infection" with its possible sequelæ.

Opposed to operation there is, firstly, no proof that the diabetes will progress in a given case if the gall-bladder is left untreated. Secondly, as stated above, though in the majority of cases the relationship between the two conditions may be causal, it might, in a given case, be accidental, and we have no accurate means of differentiating between the two types. Should the relationship be accidental, there is, obviously, no hope of improvement with respect to the diabetes, other than that which might result from the removal of a focus of infection. There is also the important fact that, compared with the other forms of the disease, diabetes resulting from disease of the gall-bladder tends to be mild. Last, but not least, there is the risk of operation. The major nature and the possible sequelæ of this surgical procedure are too well known to require further comment. Possible complications are failure of the wound to heal and the fact that either the anæsthetic or the operative manipulation may lower carbohydrate tolerance of the individual beyond control; the diabetes may become worse instead of better. From experience with hundreds of operations upon diabetics, the latter two complications are admittedly very uncommon with present-day methods of pre-operative and post-operative care. The fact, however, remains that, in spite of all presently available procedures they can and do occur.

This communication is concerned with mortality data only and is based upon the results obtained in fifty cases of diabetes complicated by chronic infection of the gall-bladder. In view of the clinical condition (absence of pain, fever, jaundice, *etc.*), none of these patients could have been regarded as "acutely ill," at least with respect to the gall-bladder condition. There were either no signs and symptoms or, at most, mild and indefinite digestive disturbances. Diagnosis in a number of cases depended largely upon laboratory data. (Blood-sugar time curves, visualization of the gall-bladder with X-rays alone or with the aid of phenoltetraiodophthalein, *etc.*) Exclusion of "acutely ill" cases was important since the purpose of this investigation was to determine whether one is justified in exposing diabetics to surgical treatment for the relief of gall-bladder disease, when not acutely ill. "Acutely ill" cases further complicate the picture because of the many factors which have to be considered, some of which are difficult to recognize, and among those recognizable, many are uncontrollable. In a few cases the diabetes was very mild; the disease could properly be classified as "potential." The group of cases thus afforded variety with respect to severity of the diabetes. The following data indicate that the patients were exposed to a variety of other conditions, also important from the practical point of view.

The operations were performed by ten surgeons. This variety, therefore, tends to eliminate the personal equation in the interpretation of operative mortality—a not unimportant consideration if the conclusions drawn are to be of practical and general value.

In the study of the results, consideration was given to age, sex, duration of operation, duration of anæsthesia and post-operative course. For comparative purposes, the last two hundred non-diabetics who suffered from chronic infection of the gall-bladder and who were operated upon were collected from the records of this hospital. Among them, twenty-one were found to have been “acutely ill.” These, obviously, had to be excluded, in order that the data might be comparable. The combined data are briefly summarized in the following table:

	GROUP			
	<i>Diabetic</i>		<i>Control (non-diabetic)</i>	
Number of cases.....	50		179	
Average age.....	51.8		47.2	
	No.	Per cent.	No.	Per cent.
Sex: Male	9	18	36	20.1
Female	41	82	143	77.9
Anæsthetic: Ether	40	80	136	76
N ₂ O	10	20	43	24
Average duration of operation..	99.5 minutes		90.5 minutes	
Average post-operative stay in hospital.....	28.2 days		26.3 days	
	No.	Per cent.	No.	Per cent.
Deaths	2	4	10	5.5

The average age of the diabetics was 51.8 years and that of the control group was 47.2 years. The data of the non-diabetic group suggested relationship between age and mortality. Thus:

<i>Group</i>	<i>Number of cases</i>	<i>Age (years)</i>	<i>Average age (years)</i>	
			<i>Recovered</i>	<i>Died</i>
Whole	200	46.3	45.7	54.5
Acutely ill	21	47.4	46.7	51.0
Note acutely ill	179	47.2	46.5	58.2

It, therefore, appears that the diabetics, because of their ages, were exposed to a greater risk of death than the control group.

The sex incidences were practically the same in both groups. The selection with respect to sex was accidental, but consideration of sex appears to be necessary since the data of the control group tended to suggest relationship between sex and mortality; males appeared to be exposed to a greater risk than females. Thus:

	<i>No.</i>	<i>Deaths</i>	<i>Per cent.</i>
Males	36	3	8.3
Females	143	7	4.9

CHRONIC GALL-BLADDER DISEASE AND DIABETES

There was variety with respect to operation. Thus:

<i>Type of operation</i>	<i>Number of cases</i>
Choledochotomy	3
Cholecystotomy	15
Cholecystectomy with drainage of common bile-duct	15
Cholecystectomy without drainage of common bile-duct	17

In forty of the fifty cases, ether was the anæsthetic used and in ten instances it was nitrous oxide. This agrees very closely with the control group in whom ether was used in 76 per cent. and nitrous oxide in 24 per cent. of the cases.

The duration of operation ranged between 50 and 150 minutes; the average duration was 99.5 minutes. This was slightly longer than the average duration for the control group, which was 90.5 minutes. The control data suggested relationship between duration of operation and mortality. Thus:

<i>Group</i>	<i>Average duration of operation</i>
Recovered	90.3 minutes
Died	113.0 minutes

It therefore appears that the diabetics, with respect to duration of operation, were exposed to a greater risk of death.

The post-operative course (healing of wounds, convalescence, *etc.*), was practically the same in the diabetic and control group. The average post-operative stay in the hospital was 28.2 days in the diabetic, and 26.3 days in the control group. This difference is attributed to the prolonged drainage of the common bile-duct which was deliberately carried out in fifteen cases. That the drainage was the chief factor to account for this prolonged period is also suggested from experiences with the control group. Thus:

Total group	26.3 days
Without drainage	20.3 days
With drainage	27.4 days

Among these fifty cases of diabetes there were two deaths. The details about causes of these deaths are irrelevant for present purposes. From the practical point of view, it may also be observed that relatives receive very little consolation when informed about the cause of death; it is the death alone which matters.

Deductions from the above statistics are difficult for a number of reasons. Firstly, the number of cases, especially among the diabetics, is too few to attach significance to percentages. (The mortality in this group was, obviously, 4 per cent., and, incidentally, less than in the control group.) In view, therefore, of the smallness of the group, it was considered advisable to express the diabetic mortality in terms of the ratio actual to expected deaths. When consideration was given to (a) the ages of the individuals at the time of operation, (b) the number of deaths, and (c) the number of individuals who not only survived operation but are still alive, the actual to expected death ratio was found to be 124 per cent. of the normal. This, it

may be observed, approximates fairly closely the actual to expected death ratios of our diabetic clinic as a whole, since the use of insulin. Thus:

<i>Year</i>	<i>Ratio of actual to expected deaths \times 100</i>
1923	280
1924	243
1925	200
1926	109
1927	107
1928	124
1929	112
1930	118

In other words, exposure of fifty diabetics suffering from *chronic* infection of the gall-bladder to operation for relief of the latter condition had an inappreciable effect upon mortality. Operation appeared to be justified by the good results obtained among the surviving individuals; all of the forty-eight patients are alive and the average period which has elapsed since operation is twenty-eight months.

Expressed in terms of insurability of the individual, life assurance companies would apply to a group of people with the aforementioned ratio of actual to expected deaths a rating of about three years. In other words, if life assurance companies could be assured of such a ratio among diabetics who are suffering from gall-bladder disease in the country as a whole, such individuals would be accepted as policy-holders and the premiums would be increased only to the extent of making the individual pay an amount as though he were three years older than his actual age. Of course, life assurance companies, as a rule, will not accept diabetics, with or without gall-bladder disease, for the simple and sufficient reason that the ratios of actual to expected deaths, in countries as a whole, are much larger than those found in hospital clinics.

In conclusion, it must again be observed that one cannot be dogmatic, in view of the smallness of the group. The purpose of this investigation was to determine whether one is justified in exposing diabetics who also have gall-bladder disease to operation for the relief of the latter condition, when not "acutely ill." The data suggest that with proper selection of cases and proper pre-operative and post-operative care of the diabetes, recommendation of surgical treatment is justified.

The writer is indebted to Dr. A. T. Bazin for his critical analysis of the surgical aspects of this investigation, and to Dr. A. T. Fowler for his collection of the data.

REFERENCE

- ¹ Rabinowitch, I. M., and Bazin, A. T.: Application and Interpretation of Blood Sugar Time Curves in the Diagnosis and Treatment of Surgical Infections of the Gall-bladder and Biliary Passages. *ANNALS OF SURGERY*, vol. xciv, p. 354, September, 1931.

FAT EMBOLISM

BY ROBERT B. WRIGHT, M.D.

OF BALTIMORE, MARYLAND

FROM THE DEPARTMENT OF PATHOLOGY OF THE UNIVERSITY OF MARYLAND SCHOOL OF MEDICINE

CAREFUL examination of autopsy material will frequently disclose the presence of fat within the capillaries of the lungs, kidneys, brain and other organs. In most instances, the fat globules are not sufficiently numerous to have produced clinical symptoms, but in some cases, especially traumatic ones, fat may exist in such quantities in the vascular system as to give definite indications as to the cause of death.

Warthin,¹ in his excellent monograph on this subject, called attention to the inadequacy of American literature on the subject as compared to European literature. He said, "the time has come that more attention should be paid to this sadly neglected branch of surgery and that the occurrence of fatty embolism after an injury to the bones be at least regarded as a possibility and that preventive means be instituted or therapeutic efforts be made whenever there is a suspicion of its occurrence." Indeed, at the present time, the charge may be made that American clinicians and pathologists in general give too little attention to so important a condition.

The author, to stimulate interest in the study of fatty embolism, offers a brief review of the subject together with the reports of two typical cases. For a history of fat embolism, reference is given to Warthin's monograph.

Endogenous fat embolism is almost always the result of physical injury to one or another of the fat depots of the body. Injury, especially fractures of the long bones, is by far the most common cause. There is no definite parallelism between the extent of trauma and the amount of fat liberated into the circulation, since fatalities are sometimes seen as a result of fracture of a single bone, while in other instances fractures of a number of long bones have not produced symptoms of fat embolism.

According to Conner² the character of the marrow fat is one of the determining factors in the production of fat embolism, for he points out that fat in older persons is more liquid, since it contains more olein, while in children, according to both Zwerg³ and Timmer,⁴ it is more cellular and contains more palmitin. This may explain why the condition is more commonly observed in persons past the age of fifty. That the condition may be seen in younger persons is shown by Utgenannt⁵ who reported a case in a child eight years of age, by Work⁶ who reported a case in a person eighteen years old, by Burns⁷ who reported a case in a person twenty-two years old, and by Ryerson⁸ who reported a case in an infant eight months old.

Orthopædic operative procedures are a fruitful cause of fat embolism. There is a long list of such references in the literature. Warthin gives

twenty-two references, while Ryerson and Timmer, to mention only a few, have also stressed this fact.

Concussion of atrophied bones has been the cause of severe fat embolism, as is illustrated by cases reported by Fields,⁹ Beitzke¹⁰ and others. Timmer states that atrophied bones at any age may contain much fat and in the very young may be the origin of the fat in fat embolism. Bissell¹¹ and Sutton¹² have reported cases following operations on the soft parts, such as radical breast amputation, umbilical hernioplasty and laminectomy. Many other references could be cited if space permitted.

Milaslavich¹³ thinks that contusions may play an important part in the

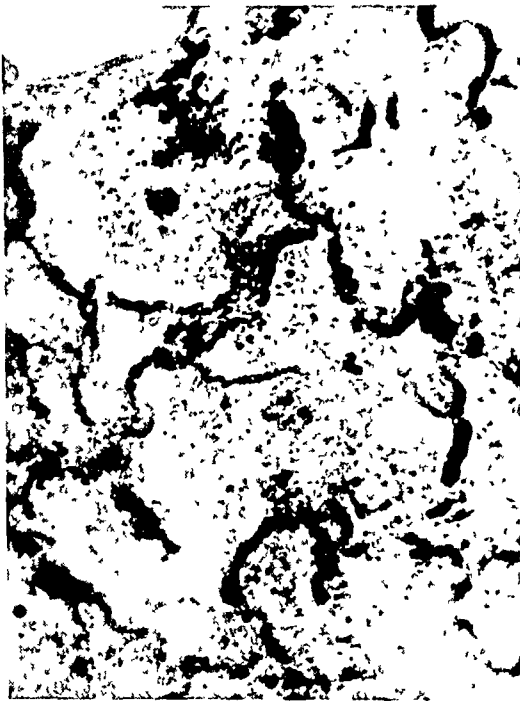


FIG 1—Fat emboli in lungs Herxheimer's method

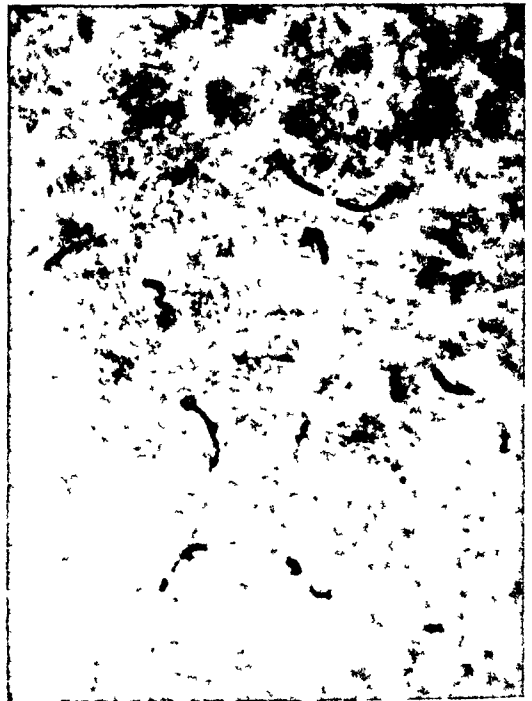


FIG 2—Fat emboli in brain Herxheimer's method

production of this type of fat embolism. This is not new, since Warthin stressed this possibility in 1913.

Fat embolism of a minor type has been reported in such conditions as pancreatitis, chronic nephritis, diabetes mellitus, chronic tuberculosis, acute and chronic alcoholism. According to Warthin and other workers, fat embolism is seldom, if ever, fatal in these conditions, unless trauma is present.

Burns and Bromberg¹⁴ and Brittingham,¹⁵ in reporting cases of death following therapeutic use of salvarsan and neo-salvarsan, suggest that in some cases, at least, the punctate hæmorrhages in the brain may be the result of the occlusion of the small vessels by fat.

Fat enters the vascular system at the site of injury where vessels are torn. The bones are ideal locations, for marrow of the long bone of the adult is rich in fat and has many vessels. It is possible that by suction fat may be

FAT EMBOLISM

drawn into the veins, or, on account of the hæmorrhage into the marrow cavity, the fat may be forced into the vessels. Fat, having entered a vein, is carried to the right heart, then to the lung, through which it may filter and pass to the left heart, to be distributed throughout the greater circulation. Instead of passing through the lung, Fromberg¹⁶ suggests that it passes through an open foramen ovale in most cases. That this is not always true is well shown by one case herewith reported.

As to the distribution of fat, much will depend on the myocardium and the capillaries of the lungs. Warthin noted many cases in which there was marked dilatation of the right heart. If the heart is powerful enough to

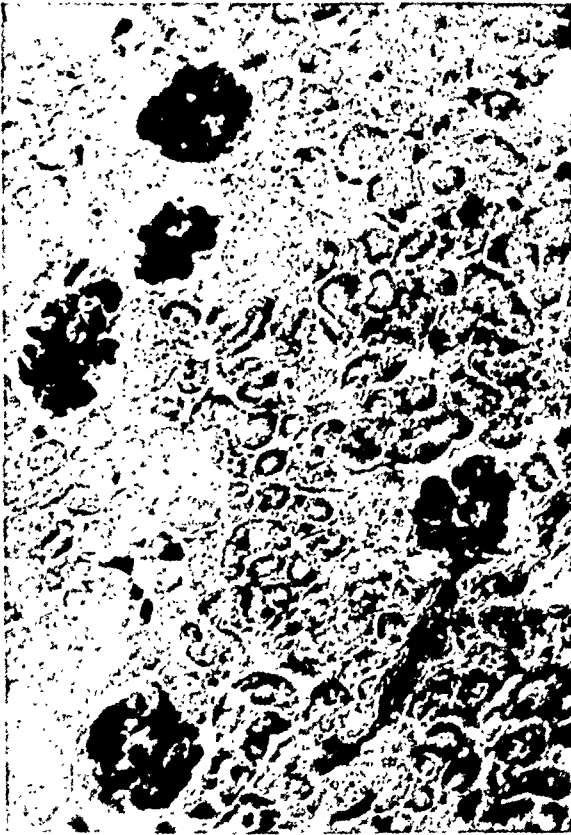


FIG. 3.—Fat emboli in the kidney. Herxheimer's method.



FIG. 4.—Kidney showing tubular degeneration. Hæmatoxylin and eosin.

push the fat through, death may not take place; on the other hand, the heart may be normal and the obstruction too great for it to overcome. It is also possible that changes in the pulmonary capillaries incident to age or disease of the lung may offer increased resistance.

There are two important factors in fat embolism; namely, the quantity of fat and the duration of the discharge of fat into the vascular system. It is easy to understand how these factors may vary and the outcome be changed. If the quantity is large enough it may not pass through the right heart and death may be instantaneous; more finely divided particles may be distributed through the lungs over a short period of time and death take place very quickly from failure of the right heart or from pulmonary œdema.

If the quantity is not too large and the right heart does not fail, much

fat may pass through the lungs and be distributed to all parts of the body. This fat, in the greater circulation, can be found in any tissue, but of course it causes symptoms from its effect on such vital organs as the heart, the brain, kidneys and glands of internal secretion.

In fat embolism there may develop in the lungs, lobular emphysema, small hæmorrhagic areas and pulmonary œdema. According to Lehmann and McNattin¹⁷ slow distribution in experimental animals will cause small collections of wandering cells, fibrosis, endothelial proliferations and sometimes miliary collections of polymorphonuclear leucocytes. In the heart there are apt to be areas of fatty degeneration in the region of fat emboli. In the brain one finds many hæmorrhages in the sub-cortical white substances, especially the corpus callosum (Gauss,¹⁸ Melchoir,¹⁹ and Fromberg¹⁶). These hæmorrhages are perivascular and at the point where a globule of fat closes the central vessel. In the kidney the glomeruli are apt to be full of fat and degeneration of the tubular epithelium may be present. According to Paul and Windholz²⁰ there may be evidence of renal disturbances. There may be small hæmorrhages in the skin and in fact in almost any organ in the body. While the above lesions are often definite, yet there are fatal cases of fat embolism with only slight gross changes, so that it is only after properly prepared histological sections are examined that the correct diagnosis can be made.

It is relatively simple to make the diagnosis at post-mortem, but it requires considerable care to determine the significance of the findings. In the laboratories here, blocks are taken from the lung and frozen sections twenty to forty microns in thickness are made and stained by Herxheimer's method for fat. In suspicious cases more than one portion of the lung and also other important organs are examined. Only low-power magnification is required, as the fat is easily seen. Relatively thick sections are made so that the fat may be held in the vessels. Examination at post-mortem should be made for fat embolism in all traumatic cases, especially if there are few or no lesions found in the gross to explain death.

The clinical pathology is quite as definite and should always be borne in mind. Fat may first appear in the sputum and later be found in the urine. Warthin says, "the presence of free fat and fat granule alveolar cells in the sputum is the earliest positive evidence of the condition being detected even before the appearance of free fat in the urine."

Fat embolism is by far the most common type of embolism. Scriba²¹ found it in 52 per cent. of all bodies. Lehmann and McNattin found it in thirty-nine out of fifty cases. In routine autopsies as done in general hospitals the best figures show around 50 per cent. of all cases to have more or less evidence of fat embolism. This, of course, does not mean that 50 per cent. die of fat embolism. Milaslavich found fat embolism in all of twenty-two cases of automobile accidents and concluded that it killed two.

FAT EMBOLISM

DIGEST OF ONE HUNDRED CONSECUTIVE AUTOPSIES

Cases in which fat was not found in the pulmonary vessels

(1) Cases without history or evidence of trauma		33
(2) Cases with history of evidence of trauma:		
Major operations	11	
Minor contusions	2	
Pregnancy with delivery	1	
Old fracture	1	15
		—
Total		48

Cases in which fat was found in the pulmonary vessels

(1) Cases without history or evidence of trauma:			
Very occasional globule	22		
1 = plus (globules in every 4-6 l.p.f.)	4		
2 = plus (globules in every 2 l.p.f.)	1		
			27
(2) Cases with history or evidence of trauma:			
(a) Very occasional globule			
Major operations	7		
Cerebral hæmorrhage	3		
Pregnancy and delivery	2		
Birth injury	1		
			13
(b) 1-plus (globules in every 4-6 l.p.f.)			
Fracture of pelvic bones	1		
Osteomyelitis, chronic	1		
			2
(c) 2-plus (globules in every 2 l.p.f.)			
Cerebral hæmorrhage	2		
Convulsions	3		
Multiple lacerations and contusions	1		
			6
(d) 3-plus (globules in every 1 l.p.f.)			
Puerperal sepsis	1		
			1
(e) 4-plus (globules in practically every capillary)			
Convulsions after cerebral apoplexy	1		
Alcoholic delirium with restraint	1		
Fracture, contusions and burns	1		
			3
			—
Total			52

In the table there is an outline of 100 consecutive autopsies performed at University Hospital. It will be noted that fifty-two had some fat in the pulmonary vessels. It can be seen at a glance the rôle played by trauma. Among these 100 cases there is no doubt that fat embolism was of a major importance in at least three, only one of which was traumatic at the onset of the fatal illness. In arranging this table a case was classified under trauma if there was any possible reason for so doing. Operations, pregnancy, and cerebral hæmorrhages were all considered as traumatic in this study.

The two cases herewith reported were not in the series of autopsies discussed in the table.

CASE I.—Mrs. B. M., Autopsy 1367, Chart No. 57879, white female, aged fifty-nine years, admitted April 18 in coma and died April 19. On the evening of April 17 the patient fell from a street car in front of her home and had to be carried into the house. The family physician found a fracture of the left hip. She was given morphia and made as comfortable as possible until the next morning. When he returned, finding her stuporous and irrational, he sent her to the hospital at once. On admission the temperature was 99° by axilla, pulse 110, respirations 22. The patient was in coma and had labored respiration, the face was drawn and there was no attempt to move. The pupils were contracted, equal, regular, and reacted to light. The right eye was rotated outward and upward, the fundi were negative. The heart and lungs were negative. The blood pressure 110/68. There was some general resistance over the entire abdomen. The extremities were definitely spastic and there were signs of fracture of the left femur. The leg was supported by pillows and she was given intravenous sugar, salt and stimulants. The temperature gradually rose to 107° by axilla, the pulse to 185, and the respirations to 40. She died about forty hours after the accident. (See temperature chart.)

X-ray Report.—Fracture with displacement, neck of femur, left. No evidence of skull fracture.

Laboratory Findings.—Urine on admission normal. Twelve hours later albumin and sugar were found. The urine was never examined for fat. Blood: red blood-cells, 4,370,000; white blood-cells, 12,500; hæmoglobin, 65 per cent.; polymorphonuclears, 86 per cent. Small lymphocytes, 8 per cent. Large mononuclears, 4 per cent. Spinal fluid, negative. Wassermann, negative. Blood chemistry: non-protein nitrogen, 29. Sugar, 93.

Clinical Diagnosis.—Fracture, neck of femur, left. Concussion of the brain.

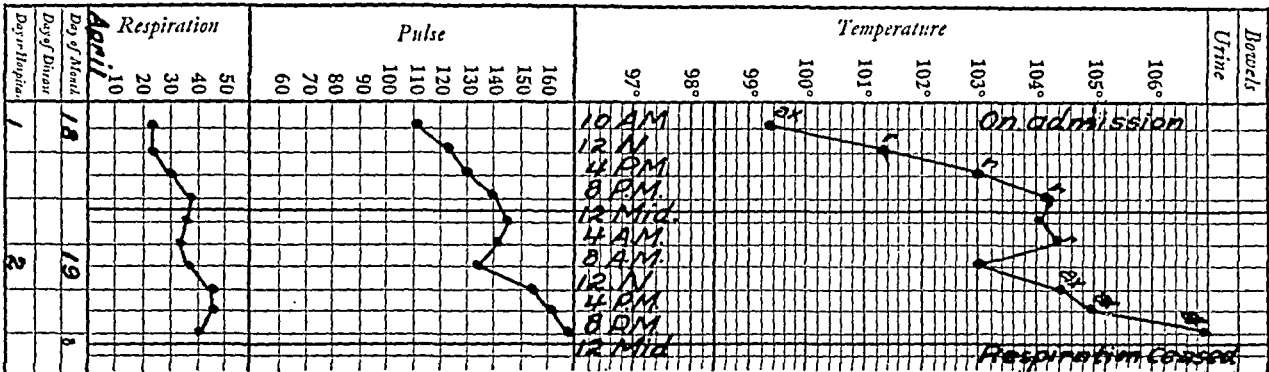
Autopsy performed one hour after death. The only positive findings in the gross were fracture of the left hip, small hæmorrhages in the brain, moderate arteriosclerosis, mild scarring of the kidneys, congestion of the lungs and abdominal viscera, bilateral hydrothorax—right, 300 cubic centimetres, left, 150 cubic centimetres, slight hydro-peritoneum, slight œdema of the ankles. The foramen ovale was anatomically closed.

Frozen section stained by Herxheimer's method for fat showed extensive embolism in the lungs, brain and kidneys. Sections stained by hæmotoxylin and eosin showed many perivascular cerebral hæmorrhages and marked degeneration of the epithelium of the convoluted tubules of the kidney. There was no pneumonia.

The above is a typical case from several points of view. Clinically, a patient in coma too often suggests only diabetes or nephritis. Not once was fat embolism considered, yet under the circumstances it was by far the most likely thing. The autopsy was performed by a man who had done but 30 or 40 post-mortems and did not suspect this condition. As soon as those who had more experience at post-mortems became aware of the case, the question of fat embolism was introduced and its existence proved a few minutes later by simple frozen section.

CASE II.—Chart No. 61170, white male, aged forty-two years. October 8, 1928, the patient sustained a fracture of the shaft of the right femur and the left humerus. These fractures failed to unite after being immobilized. January 23, 1929, an open reduction of the femur was done. When the smooth ends of the ununited fracture were broken into, a large amount of pus-like material (later found to be fat) escaped. Two hours after operation the patient went into profound shock and remained in this condition for forty-eight hours.

Temperature Chart
- Case 1



Laboratory Findings.—Urine: The urine frequently showed albumin and casts, and on January 24 and 31, large quantities of fat were present. Blood Chemistry: "Non-protein nitrogen," 30 to 39.9; urea nitrogen, 14 to 18.6; creatinin, 1.5 to 1.7; blood sugar, 111 to 118. Blood Wassermann was positive. This case ultimately recovered and left the hospital. The post-operative shock was considered to be due to fat embolism. (See temperature chart.)

From the pathology of the condition it is clear that almost anything can happen. If the greater circulation contains many globules of fat it is obvious that they may lodge in any organ and thus cause a great variety of symptoms. Clinically, in the main, there are two general types of fat embolism, namely, the one with cardiorespiratory symptoms and the other with cerebral symptoms.

The cardiorespiratory group is apt to present dyspnoea, cough, cyanosis, pulmonary oedema, even pulmonary hæmorrhage, low arterial and high venous pressure, cardiac dilatation, precordial distress, elevation of temperature and Cheyne-Stokes respiration. The cerebral type is apt to present restlessness, headache, delirium, drowsiness, stupor, coma and even convulsions. Many cases present a combination of the above.

In making the diagnosis, clinically, the most important point is to keep fat embolism in mind in every traumatic case where the symptoms are not clearly explained by definite findings. Warthin says, "fat embolism resulting from traumatic lipæmia is an important surgical condition which is not of rare occurrence but is probably at the present time, in the absence of infection, the most frequent cause of death after fractures of the long bone." Fat can easily be demonstrated in the sputum and in the urine and, as has been mentioned, it may be found in the vessels in the fundi of the eyes. If one remembers that fat embolism results from many types of trauma, especially fracture of a long bone, and that it is the extent of the embolism and the condition of the involved organ that determines the symptoms, there will be many more cases diagnosed clinically.

It is obvious that treatment of any condition so often not even considered is apt to be far from satisfactory. Diagnosis is, of course, the first step in rational therapy. All agree that shock and pulmonary oedema may demand immediate treatment, but it has occurred to but a few that a tourniquet properly applied in shock following fracture may be of much or more importance than any other procedure (Caldwell and Huber²²). Some have been so bold as to drain the thoracic duct (Wilms²³). Others have opened simple fractures, and even amputation (Melchoir) has been performed to prevent fat embolism. Such procedures in selected cases may be of value, for one is dealing with a major condition. Infusions have been used (Schanz,²⁴) with some degree of success. Porter²⁵ thinks that there is a critical diastolic blood-pressure level, below which, if the pressure fails, it does not return unaided.

To bring about a return he advocates carbon-dioxide increase in respiratory air, heat, adrenalin, elevation of lower portion of the body, infusion and

transfusion. It is generally thought that care in handling cases of fracture of long bones will do much to prevent or at least to lessen fat embolism. The Thomas splint probably has done much to reduce fat embolism in those that have to be transported after a fracture of one of the long bones.

This condition is of importance to those interested in medico-legal medicine. In Germany this aspect has received considerable stress, while in this country it is seldom considered. Milaslavich has recently reported a case where the finding of fat embolism in a body recovered from a burning dwelling was admitted as evidence in court and helped to show that the woman's husband murdered her and then burned the house to conceal the crime. There is no doubt that the medico-legal aspect of this malady has by no means been fully developed and will, as time passes, be of more and more interest to the forensic world.

SUMMARY

The clinical and pathological aspects of fat embolism are presented. Two cases are reported, one resulting in death and the other in recovery. A digest of 100 consecutive autopsies as regards this condition is presented. It is felt that fat embolism should be considered in any case where there are grave or unusual symptoms following trauma, whether the trauma be fracture, contusion, concussion, intravenous therapy, delivery or operation.

BIBLIOGRAPHY

- ¹ Warthin, A. S.: Traumatic Lipæmia and Fatty Embolism. *Internat. Clin.*, series 23, vol. iv, pp. 71-227, Philadelphia, 1913.
- ² Conner, L. A.: Embolism. *Nelson's Loose-Leaf Living Medicine*, vol. iv, p. 598, 1920.
- ³ Zwerg, H. G.: Embolism of Fat. *Beitr. z. klin. Chir.*, vol. cxli, p. 268, 1927.
- ⁴ Timmer, H.: Epileptiform Convulsions and Fat Embolism after Non-surgical Orthopedic Intervention. *Nederlandsch Tijdschrift v. Gerreiskunde*, vol. ii, No. 3, Amsterdam, July 19, 1919; (*Ab. J.A.M.A.*, vol. lxxiii, 1919).
- ⁵ Utgenannt, L.: Über Fettembolien und Krampfanfälle nach orthopädischen Operationen. *Ztschr. f. Orthop. Chir. Stuttgart*, vol. xli, pp. 393-413, 1921.
- ⁶ Dennis, W. S., and Work, P.: Multiple Fat Embolism with Report of Case. *Colorado Medical*, vol. xxi, pp. 347-352, Denver, November 24, 1924.
- ⁷ Burns, R. E.: Fat Embolism. Case Report. *Wisconsin Medical Journal*, vol. xxvi, pp. 156-157, Milwaukee, March, 1927; (*Ab. J.A.M.A.*, vol. lxxxviii, 1927).
- ⁸ Ryerson, E. W.: Fat Embolism in Bone Surgery. Incidence and Prevention. *J.A.M.A.*, vol. lxvii, p. 657, 1916.
- ⁹ Field, M.: Fat Embolism from a Chronic Osteomyelitis. *J.A.M.A.*, vol. lix, p. 2065, 1912.
- ¹⁰ Beitzke: Sur l'embolie graisseuse. *Rev. Med. de la Suisse Rom.*, vol. xxxii, pp. 501-509, Geneve, 1912.
- ¹¹ Bissell, W. W.: Pulmonary Fat Embolism. A Frequent Cause of Post-operative Surgical Shock. *Surg., Gynec., and Obstet.*, vol. xxv, No. 1, July, 1917.
- ¹² Sutton, G. E.: Pulmonary Fat Embolism and Its Relation to Traumatic Shock. *British Medical Journal*, vol. ii, p. 368, October, 1918.
- ¹³ Milaslavich, E. L.: Fat Embolism. Medico-legal Aspects. *Wisconsin Medical Journal*, vol. xxix, p. 139, March, 1930.
- ¹⁴ Burns, E. L., and Bromberg, L.: Fatal Multiple Fat Embolism in a Patient Given Salvarsan. *Am. Jour. Syphilis*, vol. xiv, p. 43, 1930.

- ¹⁵ Brittingham, J. W., and Phinzy, T.: Hæmorrhagic Encephalitis after Neo-arsphenamin. Case with Fat Embolism Found at Autopsy. J.A.M.A., vol. xcvi, p. 2021, June 13, 1931.
- ¹⁶ Fromberg, C.: Die Fettembolie des grossen Blutkreislaufes und ihr Urscehen. Mitteilungen aus den Grenzgebeiten der Medizin und Chir., vol. xxvi, p. 23, Jena, 1913.
- ¹⁷ Lehmann, E. P., and McNattin, R. F.: Pathology of Lungs in Experimental Embolism. Southern Med. Jour., vol. xxii, p. 201, March, 1929.
- ¹⁸ Gauss, H.: Pathology of Fat Embolism. Archives of Surgery, vol. ix, p. 593, November, 1924.
- ¹⁹ Melchoir, E.: Zur Keuntnis der cerebralen Fettembolie. (Fat Embolism in the Brain.) Mitteil. a.d. Grenzgeb. d. Med. und Chir., vol. xxxviii, p. 149, Jena, 1924.
- ²⁰ Paul, F., and Windholz, F.: Experimental Studies on Death from Fat Embolism. Mitteil. a.d. Grenzgeb. d. Med. und Chir., vol. xxxviii, p. 614, Jena, 1925.
- ²¹ Scriba, J.: Untersuchungen uber die Fettembolie. Deutsche Zeitschrift Chirurgie, vol. xii, p. 118, Leipzig, 1880.
- ²² Caldwell, G. T., and Huber, H. L.: Fat Embolism Following Trauma to Bones. Surg., Gynec., and Obstet., vol. xxv, No. 6, pp. 650-663, 1913.
- ²³ Wilms, M.: Treatment de l'embolie graisseuse par drainage temporaire du canal thoracique. Semaine Medicale, vol. xxx, p. 138, 1910.
- ²⁴ Schanz: (quoted from Warthin.) Zentrbl. f. Chirur., vol. xxxvii, 1910.
- ²⁵ Porter, W. T.: Fat Embolism Cause of Shock. Boston Med. and Surg. Jour., vol. clxxvi, No. 6, February 15, 1917; Am. Jour. Physiology, vol. lxxi, 1924.

ONE THOUSAND SPINAL ANÆSTHESIAS

WITH SPECIAL REFERENCE TO COMPLICATIONS AND MORTALITY*

BY HAROLD WELLINGTON JONES, M.D.

OF THE MEDICAL CORPS, UNITED STATES ARMY

FROM THE SURGICAL SERVICE OF THE STATION HOSPITAL AT FORT SAM HOUSTON, TEXAS

ONE who writes on spinal anæsthesia and who studies the literature is impressed by the fact that the last word has not been said on the subject. Some believe in it absolutely, others cry out anathemas and declare they would never submit their own bodies to the needle. Much has been written and many thousands of anæsthesias have been given, yet when some men publicly state, as one has only recently: "The more you use it the less confidence you have in it," to what can we pin our faith? The work of Labat, Babcock, Evans, Pitkin, Koster, Sise and others has been fully studied by the writer and has been most helpful in solving many of our problems. Just recently has appeared the report by Muller¹ and Overholt, of the University of Pennsylvania Hospital, based upon over 500 spinal anæsthesias, in which many of their observations very nearly parallel those reported in the present paper.

In this brief presentation I embody some results and observations in our first thousand operations under spinal anæsthesias covering a period of nearly two years. These are given under the following heads: (1) Classification of cases; (2) type and dosage of the anæsthetic agent; (3) difficulties in administration, including either complete or partial failure of the anæsthesia; (4) complications; and (5) mortality.

(1) *Class of Cases.* These, for convenience, have been divided as follows, irrespective of age, which varied from eighteen to eighty years.

(a) Operations on lower extremities, including bone grafts, amputations, insertion of tongs in fractured femurs, and various orthopædic operations, *etc.*, 121 anæsthesias.

(b) Hæmorrhoids, perineal, bladder and hernia operations, *etc.*, 386 anæsthesias.

(c) Pelvic and lower abdominal operations, kidney operations, Cæsarean sections, rectal resections, *etc.*, 323 anæsthesias.

(d) Upper abdominal operations, gastric and gall-bladder surgery, surgery of the small intestine, splenic surgery, *etc.*, 170 anæsthesias. Total, 1,000 cases.

It should be noted that we did not employ spinal anæsthesia for thoracic surgery, surgery of the breast, thyroid, *etc.*, in spite of Koster's brilliant success. We still believe nitrous oxide or local anæsthesia combined with sodium amytal is safer in the long run for the average surgeon in this class of cases.

* Read before the Association of Military Surgeons of the United States, November 30, 1931.

(2) *The Anæsthetic.* We used only three preparations, spinocaine, neocaine and novocaine. While no hard-and-fast dose was adhered to, we took as a minimum two cubic centimetres of spinocaine and as a maximum four cubic centimetres, expanded to a maximum of eight cubic centimetres with spinal fluid. As a general rule, we selected two cubic centimetres for lower extremities, hæmorrhoids and perineal operations, and from 3.25 to four cubic centimetres for other operations. In spite of using four cubic centimetres a great many times we were never able to do satisfactory routine cholecystectomies with spinocaine, although we could usually do gastric surgery without trouble and really preferred spinocaine because it seemed to depress the patients less and the anæsthesia lasted longer. For cholecystectomies during the last year we have injected neocaine and our troubles have practically vanished. At first the dose injected was 240 milligrams, but subsequently this was reduced to 200 milligrams and this is now the average dose, withdrawing eight cubic centimetres of spinal fluid. This dose is said by some writers to be high, but what is high for some patients is seemingly not high for others. Why some patients will maintain a blood-pressure of 140 under 240 milligrams of neocaine and others will sink to zero with 200 milligrams or less is difficult to explain. A cholecystectomy usually requires from forty-five minutes to an hour or more and we have found 200 milligrams of neocaine in eight cubic centimetres of spinal fluid maintains perfect anæsthesia for one hour. For using neocaine or novocaine, a large ten-cubic centimetre Pitkin syringe is perfection itself. In a few cases where we had a long operation, such as a gastroenterostomy, cholecystectomy and appendectomy in a single patient, or a tedious gastrectomy, or where relaxation was insufficient, we used ether for a short time, replacing this with nitrous oxide as we were finishing the operation.

(3) *Difficulties in Administration.* These were not inconsiderable. The average writer who gives us the benefit of his experience in spinal anæsthesia is slow to admit that he has any difficulties, but we are still having them after considerably more than 1,000 anæsthesias. With neocaine or novocaine there is usually no trouble if the spinal fluid runs at all. With spinocaine, to get proper mixing of the spinal fluid with the anæsthetic is sometimes not possible. In some stiff spines with chronic spondylitis it is practically impossible to use spinal anæsthesia. In an occasional case in which spinocaine was used and where there was no failure in technic, no anæsthesia was noted and there was no relaxation whatever in thirty minutes. We have seen an occasional patient so nervous that a general anæsthetic seemed almost necessary in order to give a spinal. On the whole I think it can be said that the use of procaine crystals dissolved in spinal fluid is easier and certainly much more sure in action than spinocaine—in fact, we never had a real failure with neocaine. Spinocaine, however, to most observers will *seem* safer at least, because with this agent we do not experience the complete drop in blood-pressure and apparent prostration, and, of course, one is never hurried with spinocaine because the anæsthesia lasts usually two hours or more. I should say we

have had 100 per cent. satisfactory anæsthesias in perineal and orthopædic work and perhaps slightly over 90 per cent. in lower abdominal work, using spinocaine. To put it succinctly, spinocaine would be the perfect spinal anæsthetic if it were always sure of producing complete anæsthesia, and neocaine would be the perfect anæsthetic if the anæsthesia would last twice as long.

(4) *Complications.* Under complications I have listed all symptoms and physical signs which seemed to be at all important or to cause anxiety, whether immediate or remote, and whether or not we were sure they were caused by the spinal anæsthesia. These were as follow, more or less in order of frequency: (a) Nausea, vomiting; (b) collapse, weak pulse, no blood-pressure, loss of voice, extreme pallor; (c) headache, sciatica; (d) respiratory failure; (e) lung collapse.

(a) Nausea either alone or occasionally associated with vomiting occurred in at least 15 per cent. of the cases, more rather than less. It is quite possible had we routinely used large doses of sodium amytal pre-operatively with pantapon instead of morphine the number would have been appreciably smaller, but I doubt it.

It was seldom troublesome enough to delay the progress of the operation but there were a number of cases in the series in which nausea and straining were prolonged. If this did not yield to ice on the head, aromatic ammonia fumes and oxygen were administered, and, if these failed, ether was given. It is freely admitted that where nausea and straining persists, even if ever so little, this may seriously interfere with some tedious and delicate abdominal operations, such as lumbar sympathectomy, for instance, but it is seldom that it really does. If vomiting persisted after return from the operating room, it usually yielded to mild measures in a few hours. It was never a feature after twenty-four hours.

(b) In a very small number of cases, not over half a dozen, in which elective operations were done, there were observed some alarming symptoms. One of these was a cholecystectomy in which 200 milligrams of neocaine were used, another was an attempted cholecystectomy in which four cubic centimetres of spinocaine were used and this had to be reinforced with ether before the completion of the operation. The others were abdominal operations with four cubic centimetres of spinocaine. In only two was there complete loss of voice, but in several there was noted a "crowing" voice. Every case responded immediately to intravenous salt solution with inhalations of CO₂. The alarming symptoms came on generally about ten or fifteen minutes after the anæsthesia was begun.

(c) Headache was never a prominent symptom. We had only one very severe headache lasting a week. The others were all relatively mild and few in number, lasting usually five or six days. Sciatic pain occurred only occasionally, but one case being of any severity. This one case, however, took six months to recover.

(d) Respiratory failure occurred in but one instance, although there were

a number of cases in which the respiration dropped to 5 or 6. This was a nephrectomy in which four cubic centimetres of spinocaine were used in a frail woman of fifty weighing but 100 pounds. It was noted at the time she was moved from her side to her back at the conclusion of the operation. She required artificial respiration and oxygen but the symptoms disappeared in two hours, only to reappear at the end of twenty-four hours and again in three days. This patient died on the fourth day. No autopsy was obtained, in spite of urgent requests.

(e) Lung collapse seems to occur quite frequently after spinal anæsthesias, practically always after abdominal operations. Whether it is more frequent than after inhalation anæsthetics I cannot say, but I am beginning to believe it is. At all events, in many cases in from twenty-four to forty-eight hours after a simple appendectomy, for instance, the temperature rises to 102° or 103° with respiratory distress and an X-ray shows the collapsed lung with the heart displaced. I am sorry I cannot quote statistics, for we missed many early cases in the series and thought they were aborted pneumonias, pleurisies, *etc.*, because the patients got well so promptly. Spinal anæsthesia is no protection against lung collapse but lung collapse seems almost never fatal no matter how ill the patient seems to be. Since August of this year when we began to X-ray all suspicious cases we have had six lung collapses after spinal anæsthesias, a percentage of 4.3, considering solely the cases of abdominal surgery, since the lung collapses occurred in no other class of cases. We have also had collapses after general anæsthesias. No case of lung collapse, or, indeed, of any grave complication, occurred in the 300 or more anæsthesias in which only two cubic centimetres of spinocaine were used. We have only recently used CO_2 inhalation as a preventive of atelectasis as advocated by Graham, and cannot give an opinion as to its value except as a respiratory stimulant where the respirations fall too low for safety. Apparently the dose of spinal anæsthetic may have some bearing on lung collapse but there are too many other factors present for us to be sure. These factors are, of course, the type of operation, the use of morphine, scopolamine and sodium amytal and so on.

(5) In considering the mortality I have tried to be honest, for I feel that the continued use of spinal anæsthesia or its discontinuance for general use will depend to a large extent on the honesty and freedom from bias of the reports. At our hospital we have endeavored to surround the administration of the anæsthetic with due precautions. If we err in technic, in the selection of cases for spinal anæsthesia and in dosage, we want to know it. In discussing mortality I include all deaths during the two years covering the report occurring within three days of the administration of a spinal anæsthetic, even though the anæsthetic is supposed to be eliminated in from six to eight hours. At the outset we may say we have had no death on the table or within three hours of the administration of the anæsthetic, and we do not believe we have had any case in which we can be certain that spinal anæsthesia caused death or even contributed to a fatal issue in the entire series. The list of deaths with details is placed at the end of the report, there having been a total of

fourteen during the period of two years covered by it. In studying these deaths I think any fair-minded critic would certainly dismiss all but Cases III, V, IX, and X as having been not influenced in any way to a fatal issue by the spinal anæsthesia. In my own opinion, Cases III and V and possibly IX (all of them are women) are the only ones in the series where we could even assume for the sake of argument that the type of anæsthesia had anything to do with the result. Of course, if one gives a spinal anæsthetic and the patient promptly dies with certain symptoms, we can say *post hoc propter hoc*, and lay the blame upon the anæsthetic, but we have had no such case. We all know that in a few hours after a spinal anæsthesia, sensation returns and the effects of the anæsthetic have apparently disappeared. What, then, is our time limit in placing responsibility for any untoward event that may occur? I make no attempt to answer this.

In examining these three deaths more in detail, Case III was a young woman, a blonde so pronounced as to look a little like an albino. She had had two children and looked and seemed in good general health. She had been under observation on the Medical Service of the hospital for some time for survey and was regarded as a good risk. Her death was fairly sudden as she showed none of the alarming symptoms on the table and left the operating room smiling and talking to her husband and with a normal pulse and respiration. In the first twenty-four hours we were not even aware of the fact that her convalescence was not proceeding normally. Her death was preceded by increased respiratory rate, staring eyes, rapid pulse and loss of consciousness. There was slight dilatation of the stomach but no vomiting nor rise of temperature. I cannot believe the anæsthesia influenced her death but it was difficult to see why she died. After her death it was discovered that she had been exceedingly fearful of the operation. How much fright contributed to her death no one knows. Case V was the only one in the series where I felt that we had a suspicion that spinal anæsthesia had any part in the result. This patient was a very frail woman, manifestly and admittedly a poor surgical risk. She received a full four cubic centimetres of spinocaine but beyond a pronounced drop in blood-pressure and loss of voice she showed no symptoms causing apprehension during the operation in which the kidney was removed. As soon as she was turned from her side to her back, respiration practically ceased, although the patient was perfectly conscious. She kept whispering that she could no longer breathe. She responded to artificial respiration, oxygen and CO₂ but was kept on the table for an hour, after which she was sent to the ward. She had another similar attack in less than twenty-four hours but again recovered and seemed to be doing well for a while but at the end of the third day she suffered a third seizure with respiratory failure and died in a few hours. Had her death occurred in the first twenty-four hours, as it very nearly did, we would unquestionably have laid it at the door of spinal anæsthesia, but, occurring as it did, after seventy-two hours, we could not be sure. The blood chemistry was practically normal and since an autopsy was refused her death was recorded as due to cerebral embolism, which seemed as reasonable as to charge it to the anaesthetic. Case IX was an elective operation in a woman who had been operated on before under a general anæsthetic but who had had such a bad recovery following ether that we advocated spinal. She was very talkative, extremely apprehensive and was exactly the type which gets you into trouble. She had a comparatively simple operation entirely in the pelvis and did well on the table. Almost immediately, however, she began to show danger signals, rapid pulse, restlessness and semi-delirium. An ileus developed rapidly. An ileostomy was done under local anæsthesia but the patient went from bad to worse and died in sixty hours. Autopsy diagnosis was paralytic ileus. Case X needs only scant mention. This patient died in forty-eight hours after a cholecystectomy with the familiar complication, high

temperature, rapid death. For many years I have been accustomed to have an occasional patient who unexpectedly developed a temperature of 105° to 107° about two days after a cholecystectomy and this seemed to be one of these cases. Nothing about the case indicated that the anæsthetic played any part in it.

I have purposely laid all the information in these deaths on the table for all those interested to study, not that I desire to emphasize them but because I do not wish to present a paper on spinal anæsthesia and in conclusion say with finality so that none can say me nay: "There were no deaths from the anæsthetic." The reader is therefore at liberty to draw his own conclusions as to the danger or safety of spinal anæsthesia in these 1,000 cases.

A celebrated surgeon once said, you may remember, that "With statistics you can prove anything, even the truth." Therefore, in closing, I shall quote a few statistics without trying to draw conclusions. In two years we have had no mortality in Cæsarean section, in ruptured gastric and duodenal ulcer or in gastric and intestinal resections where we used spinal anæsthesia. In the last year we did 246 consecutive appendectomies under spinal anæsthesia before we had a death and we also did thirty operations on the gall-bladder and bile-ducts, practically all cholecystectomies with but two deaths, both forty-eight hours post-operative, and one of these was complicated with multiple liver abscess. When I examine our mortality record in the years prior to 1930 and 1931, while of course the surgery done does not exactly parallel these two years, I am nevertheless convinced, without trying to be persuaded, that we could hardly match our record with any other anæsthetic. We must remember, also, that no mention has been made of many cases such as multiple intestinal resections for gunshot wounds of the intestine, appendectomies in the presence of pneumonias, and so on, where death seemed almost certain had not spinal anæsthesia been available.

Finally, I wish to say that I think our best defense of spinal anæsthesia, if it really needs any defense, is that we are continuing to use it. Certainly it is a boon for the ordinary surgeon because it makes him at once a far more skilful operator on account of the quiet abdomen in which he works. For fractures of the lower extremities it is a Godsend, and a medical student can put up a femur perfectly well under spinal anæsthesia. An amputation of the thigh under two cubic centimetres of spinocaine seems like a minor operation, almost, and we have done five consecutive thigh amputations with no mortality under spinal anæsthesia. In the military service it should be used universally both in peace and war for practically all surgery of the lower extremities where a small dose is sufficient. However, it is a sharp-edged tool and a jealous mistress and in the higher doses and in upper abdominal surgery it should be employed only by those skilled and experienced in its use. It makes for better surgery and for smoother convalescence, but it is not fool-proof, it will not make something out of nothing and the day will not come, in my opinion, when it will entirely supersede all other types of anæsthesia.

BIBLIOGRAPHY

¹ ANNALS OF SURGERY, vol. xciv, p. 738, November, 1931.

SPINAL ANÆSTHESIA

TABLE I

Deaths which Occurred from All Causes in the Series of One Thousand Cases in which Spinal Anæsthesia was Used. All Cases Dying within Three Days are Included

Case	Diagnosis	Operation	Circumstances of Death
(I) W. D. D., 45. Retired of- ficer, U.S.A.	Intestinal obstruction, acute (three days' duration) from volvulus of small gut; <i>in extremis</i> when first seen.	Right rectus incision through old abdominal scar. Omental adhesions separated. Entire small gut from upper jejunum to ileocaecal region enormously distended and ileum dark. Small bowel drained in six or seven places with trocar and catheter and openings closed. Bowel milked of two or three quarts of contents. No definite point of obstruction found.	Death forty-eight hours post-operative. Toxæmia from obstruction.
(II) C. H., 37. Soldier	Massive hæmatoma in gastric colic omentum size of grapefruit extending behind posterior wall of stomach to diaphragm on left. Ruptured pancreas. Accidentally incurred by being kicked by a horse in abdomen.	Incision and drainage of hæmatoma. In evacuating contents of about 700 cubic centimetres stomach wall turned out through rent in the mesentery and ascertained to be uninjured. Pancreas was badly torn, no repair was possible.	Death forty hours post-operative. Rupture of pancreas.
(III) Mrs. D. H., 30	Appendicitis, chronic. Retroversion uterine, severe.	Mid-line incision; appendectomy. Suspension of uterus, modified Gilliam. Dilatation and curettage.	Statuslymphaticus. Death forty hours. Autopsy did not disclose cause of death.
(IV) V. C., 25. Soldier	GSW perforating abdomen. Wound of entrance level of umbilicus eight centimetres to left. Wound of exit right gluteal region with multiple perforations of mesentery and small intestine. Peritoneal and retro-peritoneal hæmorrhage.	Laparotomy with repair of intestinal and mesenteric perforations; closure with drainage. Saline 2,000 cubic centimetres intravenously. Two blood transfusions; one before operation and one following.	Death in twenty-four hours from shock of multiple gunshot wounds.
(V) Mrs. C. W., 50	Nephrolithiasis, right.	Nephrectomy. The pelvis of the kidney contained a large staghorn	Cerebral embolism.

HAROLD WELLINGTON JONES

TABLE I (*Continued*)

Case	Diagnosis	Operation	Circumstances of Death
		stone filling calyces and pelvis. Kidney functionless and pelvis so damaged the kidney was removed. Serious respiratory embarrassment occurred on the table.	
(VI) H. L. T., 37. Soldier	Contusion, severe, abdominal. Fracture of 6, 7, 8, 9 ribs, axillary line, left. Rupture of ileum with multiple contusions of ileum and traumatic peritonitis. General peritonitis. Wound, lacerated, left groin.	Abdominal section, left rectus 10-inch incision. Repair of ruptured ileum with end-to-end anastomosis. Drainage. Operation performed twenty-four hours after injury.	Patient died of general peritonitis with tetany three hours after operation concluded.
(VII) R. B. L., 35. Officer, U.S.A.	Cholecystitis, chronic, suppurative. Persistent sinus at site of cholecystostomy in December, 1930.	Right rectus incision; cholecystectomy.	Hepatitis, acute, with early abscess formation. Myocarditis, acute, toxic severe with cardiac dilatation. Localized peritonitis. Temperature 105° at death.
(VIII) F. W., 70. Veterans' Bureau Beneficiary	Intestinal obstruction (ileus) acute, due to acute cholecystitis. Complicating myocarditis, chronic. Nephritis, chronic.	Abdominal section, right rectus incision. Small intestine showed recent signs of recent distention. Gall-bladder buried in omental adhesions, would not empty and contained stones. Obstruction relieved manually and by spinal anæsthesia. Bowel movement on table.	Death thirty-six hours. No further cause found at autopsy other than set forth in complications.
(IX) Mrs. F. L., 34	Retroversion, uterine, severe. 2, Cysts, multiple, ovarian, left. 3, Adhesions of colon to broad ligament.	Mid-line incision; suspension, uterine, Gilliam method. Separation of adhesions. Removal of ovarian cysts.	Paralytic ileus. Death sixty hours post-operative. Autopsy, diagnosis confirmed.
	Post-operative ileus (forty-eight hours)	Ileostomy to left of umbilicus. Coils of ileum were moderately distended and red, but there was no evidence of peritonitis.	

SPINAL ANÆSTHESIA

TABLE I (*Continued*)

Case	Diagnosis	Operation	Circumstances of Death
(X) T. O. B., 36. Veterans' Bureau Beneficiary	Colitis, spastic, mild, cause undetermined. 2, Cholecystitis, chronic. 3, Cholelithiasis.	Cholecystectomy, tube drain. Gall-bladder contained numerous small stones. It was embedded in omental adhesions.	Myocarditis with failing compensation. Temperature 106° at death.
(XI) C. B. S., 24. Soldier	Rupture, traumatic, upper jejunum. Severe contusion, left side of chest. Collapse of left lung. All due to accidental trauma.	Left rectus incision; closure of rupture in jejunum; two rows of sutures. Jejunostomy just below point of rupture. Closure with No. 16 catheter in jejunum.	Pneumonia broncho all lobes both lungs. General peritonitis. Autopsy diagnosis.
(XII) J. D. P., 42. Soldier	Acute surgical abdomen, type undetermined, manifested by extreme epigastric pain, vomiting and upper abdominal rigidity.	Exploratory laparotomy. Acute pancreatitis.	Acute hæmorrhagic pancreatitis. Death eight hours post-operative.
(XIII) G. C. B., 40. Veterans' Bureau Beneficiary	Appendicitis, acute, suppurative, with general peritonitis.	Appendectomy; grid-iron incision. Appendix was removed in fragments, retrocæcal.	General peritonitis. Death thirty hours post-operative.
(XIV) J. B., 31. Soldier, Air Corps	Appendicitis acute, suppurative, with general peritonitis.	Appendectomy; grid-iron incision, free pus, drainage.	General peritonitis. Death seventy-two hours post-operative.

ACUTE INTUSSUSCEPTION IN INFANCY AND CHILDHOOD

A REVIEW OF SIXTY-FOUR CASES

By EDWARD W. PETERSON, M.D., AND RUPERT FRANKLIN CARTER, M.D.
OF NEW YORK, N. Y.

DURING the past twenty-four years the patients in this group of sixty-four cases have made up the principal subject matter in several papers: Two on acute intestinal obstruction and two on intussusception alone. The study of a series of patients as they occurred over a period of twenty-four years and the contrast presented by the present additional eighteen cases to the previously reported forty-six bring out interesting points in the factors of diagnosis, treatment and mortality percentages.

The present group of eighteen cases that have occurred on our service since the last report in 1922 were operated upon by: Doctor Peterson, seven; Doctor Silleck, three; Doctor Salisbury, three; Doctor Carter, five.

Age.—In the new series of eighteen cases, thirteen occurred in infants under twelve months of age and five in the second year, the youngest in the series being three months old and the oldest two years. In the previously reported cases, thirty-nine were in infants under thirteen months of age and seven in older patients of from twenty months to eight years, the youngest being six days old and the oldest eight years.

Sex.—There were ten males to eight females in the new group; and in those previously reported there were thirty-one males to fourteen females.

Clinical Picture.—In the previously reported cases, the past history is classified by the general condition of the child and the physical condition of thirty-six of the infants was given as being exceptionally good, two in fair shape and one subnormal. The majority were breast-fed and only two were on artificial feedings exclusively.

A review of the past history of the eighteen recent cases reveals: No abdominal symptoms in eight cases; constipation in four cases; vomiting attacks in five cases; cramp attacks in three cases; diarrhœa with bloody streaks of mucus in four cases; and in three cases there had been definite attacks of vomiting, abdominal pain and diarrhœa with blood in the stools. In one case the attack occurred one week before, in another two months before, and in a third there had been attacks of this kind over a period of three months before the final complete obstruction occurred.

The present history of the additional eighteen cases in which the symptoms are recorded in every instance shows: Pain recorded as cramps or pain in nine cases; vomiting in eighteen, fecal in one; bloody mucous stools in eighteen, either before or after coming to the hospital. On examination a mass was recorded as being present in fifteen cases; five situated in the right lower quadrant, four in the right upper quadrant, three in the upper

quadrant, one in the left upper quadrant, and two were felt only by rectum. The average duration of the onset of the symptoms was thirty-two hours; there were two having had symptoms of 120 hours and two with symptoms of nine hours' duration. Twelve cases had had symptoms for twenty-four hours or longer.

In the discussion of those symptoms as given in the previously reported cases, pain was uniformly present; vomiting in every case; bloody mucous stools in about 95 per cent.; and a tumor was felt in every case with but two exceptions.

A comparison of the past history between the present and previous groups of cases cannot be accurately made because of the differences in the history charts, but many of the old histories were worthless and it was only by subsequent questioning of some member of the family that the true story was obtained.

In the present histories the degree of shock and general appearance mentioned in the old reports could not be brought up to date except by an opinion just as that given previously had been, and shock in the early cases depends on the amount of strangulation of the mesenteric blood supply. Invagination without strangulation gives practically no shock in the early hours.

In the previous cases pain was given as being uniformly present; pain occurs in every case of intestinal obstruction, and closer questioning would probably show that it was present in all eighteen cases in this last series, and in the present group it was recorded in nine instances; vomiting was present in every case in both groups; bloody mucous stools in forty-four of the old forty-six cases and in eighteen of the present eighteen; a tumor was felt in forty-four of the forty-six old and eighteen of the eighteen new cases.

Etiology.—In the majority of instances of reports on intussusception there has not been given a cause of sufficient frequency to become suggestive as an underlying principle or real cause for the invagination. In the old groups of this series of sixty-four cases there was noted in two a Meckel's diverticulum as a causative factor; in one a cyst adenoma of the cæcum; in another an inflammatory thickening of the lower ileum, not involved in the intussusception. Appendicitis was given as a probable cause and the removal of the appendix was recommended in the first of these reports in 1905. Enlarged mesenteric lymph-nodes were mentioned but not given as a cause but rather as a result of the intussusception.

In the present group of eighteen cases there was only recorded an instance of enlarged lymph-nodes as an additional factor. The appendix, however, was removed in every case but two; one of these was in an irreducible case that died on the table. The pathological report of the appendices removed showed in nine cases subacute inflammatory changes; in two, chronic inflammatory changes; in two, acute appendicitis; in one, gangrene;

in one, congestion; in one, a normal appendix, and the record was lost in one case.

Varieties of Intussusception.—In the previously reported cases there were according to the classification as suggested by Clubbe: Enteric, three cases; Ileocecal, thirty-one cases; enterocolic or double intussusception (entero-ileocecal and ileocolic-colic), eight cases; colic, two cases; and, in two cases that were not operated upon, the type was not recorded. In the present group of eighteen cases there were: Enteric, no cases; ileocecal, five cases; entero-colic or double intussusception, eleven cases; colic, one case; unclassified, one case.

Gangrene.—In the previous reports on forty-three cases there were fifteen cases in which there was either gangrene or an irreducible intussusception present requiring a resection. In the present group of eighteen cases there were two with gangrene that were also irreducible.

Operation.—In the previously reported cases, one case died as the operation was begun; one case died prior to operation; one case reduced without operation; twenty-eight cases were reducible; and fifteen cases required resection. In the present group, all the cases were operated upon; one case died on the table with an irreducible intussusception; sixteen cases were reducible; and one case with an irreducible intussusception required resection.

Mortality.—In the forty-three cases previously reported, there were twenty-two cures and six deaths (from all causes to three weeks after operation), a mortality of 21.42 per cent. in the cases in which reduction was possible. And in the fifteen cases requiring resection, there were four recoveries and eleven deaths, a mortality of 72.4 per cent. In the present group of eighteen cases, there was one death in sixteen reducible cases, or a mortality of 6.25 per cent., one death on the table in an irreducible case that was moribund and one recovery from a resection of a gangrenous appendix, cæcum and ascending colon.

For the entire series of sixty-four cases, among the reducible cases there have been thirty-eight recoveries and seven deaths, or a mortality of 15.5 per cent., and among the irreducible cases there have been five recoveries and twelve deaths, or a mortality of 76 per cent.

There were sixty-one cases operated upon for intussusception, with forty-two recoveries and nineteen deaths, or a total surgical mortality of 31 per cent.

In the previously reported group of patients, there was one death in an infant that was seen within the first forty-eight hours of the onset of symptoms, death being due to influenza pneumonia.

In the added group of eighteen cases there were no deaths in those patients in which the operation took place within forty-eight hours of the onset of symptoms. There was one death in a reducible case in which the infant expired ten hours after reduction of an enterocolic intussusception that took place in the hospital while the child was under observation for the diagnosis of rectal polypii which were not present.

INTUSSUSCEPTION IN INFANCY

In the previously reported cases, the diagnosis by X-ray was mentioned and advocated as a differential diagnostic means in doubtful cases. In this series it was employed in two instances: in one a gastro-intestinal series showed an obstruction in the lower ileum in an infant that had been having symptoms of partial obstruction for two months. Operation revealed a gangrenous intussusception. A Friedrich operation was performed with a lateral anastomosis between the ileum and transverse colon with recovery and normal function to date, two years afterward.

In the second case in which a probable diagnosis of rectal polpi had been made and in which sigmoidoscopical examination revealed no polypus, a barium enema showed an obstruction in the left colon and later a mass was demonstrated and the diagnosis of intussusception made.

In every instance in this last series of eighteen cases the diagnosis of intussusception was made and recorded before operation.

SUMMARY

The continued occurrence of intussusception in spite of the great improvements in feeding with the decrease in cases of diarrhoea among infants retains this condition in that group of diseases for which active treatment instead of prevention must prevail.

Preparation for operation still is limited because of the severity of the condition together with the acute onset and the delay in diagnosis and operation.

In recurring intussusception or intussusception without obstruction or strangulation of the blood supply, the X-ray is an aid in diagnosis, but the barium enema should be given first.

Operation upon patients with strangulation, obstruction and gangrene still carries a high mortality when every means of treatment of these conditions is employed; and, though an occasional patient may survive the resection of intestine, the only means of reducing the high mortality in these patients is by operating for the intussusception before gangrene occurs.

BIBLIOGRAPHY

- Peterson, E. W.: Acute Intussusception in an Infant. Resection of Gangrenous Intussusception. Recovery. Med. Record, March 4, 1903.
- Peterson, E. W.: Remarks on Acute Intestinal Obstruction with Special Reference to Intussusception. Med. Record, September 12, 1908.
- Peterson, E. W.: The Danger in Delay in the Diagnosis and Treatment of Intussusception in Infancy. Med. Record, February 6, 1915.
- Peterson, E. W.: Acute Intussusception in Infancy and Childhood. Transaction of Section on Surgery of the American Medical Association, 1921.
- Peterson, E. W.: Intestinal Obstruction in Children with Special Reference to Intussusception. N. Y. State Jour. of Med., July, 1916.
- Peterson, E. W.: Acute Intestinal Obstruction in Infancy and Childhood. Surg., Gynec., and Obst., October, 1922.
- Silleck, Walter M.: Intussusception in Infancy and Childhood with the Report of a Successful Case of Resection for Gangrenous Intussusception. Med. Record, May 28, 1921.

PERICOLIC MEMBRANES *

By WARREN L. DUFFIELD, M.D.

OF BROOKLYN, N. Y.

FROM THE SURGICAL SERVICE, ST. JOHN'S HOSPITAL

IT HAS been said that there are two kinds of appendicitis—acute appendicitis and appendicitis for revenue only—and it is to those cases of the revenue group, incorrectly diagnosed as chronic appendicitis, that we wish to call your attention.

There are four separate and distinct types of membranes occurring with relative frequency in the lower right abdomen:

First.—Post-operative adhesions with which we are not now concerned.

Second.—The so-called Jackson's membrane involving the upper ascending colon and at times nearby portions of the transverse colon. We are told that these are formed to afford additional support for the large bowel in cases of enteroptosis. This may be in some instances but in others we believe them to be due to an entirely different cause of which we will speak later.

Third.—The so-called Lane's band found within the last 12 to 14 inches of the ileum. These are unquestionably congenital.

Fourth.—Pericolic membranes involving the cæcum and lower part of the ascending colon.

It is the last-mentioned variety that we wish particularly to emphasize. They were first described by Jonnesco but unfortunately at a time when the thought of the entire world was focused on the European War and they have not received the attention they merit. Aside from Jonnesco's article there is practically no literature on the subject with the exception of an article by Bigelow, of Brandon, Manitoba, appearing in the July, 1930, issue of the Canadian Medical Association Journal. He reviews 1,027 cases of his own but in his short paper confines himself largely to the one symptom of lower right abdominal pain.

The larger surgical text-books treat the subject with but scant courtesy and, in our judgment, entirely miss the point by advising against all interference with such membranes (usually only mentioning Jackson's) unless they are causing obstruction.

Paradoxical as it may sound and seem pericolic membranes, at certain ages, may produce mild obstructive symptoms, obstinate constipation, without directly producing obstruction. Their effects are definitely reflex, affecting the pylorus and transverse and descending colon as has been demonstrated repeatedly in approximately 200 personal cases on which this paper is based.

Pericolic membranes are undoubtedly congenital and consist of a reduplication of the parietal peritoneum extending up on to the side of the cæcum and from which they can be separated with a few light touches of a scalpel

* Read before the Brooklyn Surgical Society, February 4, 1932.

which causes no bleeding. Frequently they extend around the lower end of the cæcum and here have a tendency to shorten the meso-appendix and produce angulation. Less frequently they extend up the ascending colon and become blended with Jackson's membranes if these have been developed.

In our series of cases females constituted 68 per cent. and males 32 per cent. Fourteen per cent. occurred in the second decade, 44 per cent. in the third decade, 23 per cent. in the fourth decade, 11 per cent. in the fifth decade and 5 per cent. were over fifty years of age. Thus it will be seen that 67 per cent. of cases were between the ages of twenty and forty.

In approximately 10 per cent. of our cases the appendix had previously been removed, leaving the patient with the same symptoms which existed prior to its removal. This figure corresponds with Bigelow's experience, he having 107 cases of previous removal of the appendix out of a total of 1,027 cases.

The symptomatology varies with the age of the individual but constipation is usually, though not invariably, present and the membranes are more common in the thin, flat-chested individual, the subject in whom an enteroptosis would be expected. We have sectioned the membranes in a fairly large number of such patients and have been gratified by having them put on so much flesh that no further treatment for the enteroptosis was needed.

If we classify symptoms according to age groups we shall obtain a clearer picture.

Decades	2nd	3rd	4th	5th	6th
Constipation.....	53%	53%	58%	64%	59%
Right iliac pain.....	100	83	64	42	57
Right iliac tenderness.....	70	58	50	35	42
Nausea.....	23	37	29	21	29
Vomiting.....	17	19	22	28	42
Epigastric pain.....	0	19	32	35	42
Flatulency.....	0	32	22	42	29
Digestive disturbance.....	6	11	13	21	14

(The term "digestive disturbance" has been used to cover the more-or-less indefinite complaints of epigastric fullness, heaviness, etc.)

First it will be noted that constipation is present in more than 50 per cent. of the patients of all ages. The local and reflex symptoms show interesting variations. Right iliac pain and tenderness are complained of in a large percentage of those in the second and third decades but diminish in the later decades. Nausea and, particularly, vomiting are increasingly present with increasing age as are also epigastric pain and flatulency. In brief, as age increases the local right iliac symptoms become less and the reflex symptoms caused by pylorospasm increase.

As might be expected there is no alteration in pulse, temperature nor blood count.

The typical history is one of recurring attacks of lower right abdominal pain and tenderness (varying with the age) and frequently made worse by exercise. Seldom is there a history of an attack sufficient to demand rest in bed. Later in life the attacks are more suggestive of gall-bladder disturbance

or duodenal ulcer and most of the older patients can be temporarily relieved by alkalies and antispasmodics.

Physical examination is essentially negative except that where tenderness is present it is usually diffused over the cæcum and ascending colon.

The Röntgen-ray findings are typical and convincing but are frequently overlooked or misinterpreted. Doctor Knapp, our röntgenologist at Saint John's Hospital, prefers to depend largely upon the fluoroscope for the stomach examination and this we have found highly satisfactory, though usually a few pictures are made as a matter of record. The stomach is usually hypermotile with almost invariably a marked pylorospasm frequently causing a small six-hour residue.

The cæcum is usually smooth, particularly on its outer border, and its lower extremity cone shaped. The usual incisures in the ascending colon are shallow or absent, giving the impression of a bowel surrounded by an invisible veil limiting peristaltic action. There may be reduplication and fixation at the hepatic flexure and here again the fluoroscope comes into play in determining whether the ascending and transverse colon are actually adherent in a sharply angulated position. Almost constantly there is marked spasticity and contraction of the distal transverse colon and the descending colon. The ileum usually enters the cæcum at a very acute angle and there is frequently a marked ileo-cæcal delay—a small bowel constipation.

Returning to the subject of Jackson's membranes, which we are told have been developed to hold up a right colon which is falling into the pelvis we stated earlier in the paper this may be so in some cases but it certainly is not true in all, for in many of our cases we find the cæcum in a normal or even high position with no signs of enteroptosis but with Jackson's membranes much in evidence. What we do find in practically all cases (by X-ray) is a markedly spastic transverse or descending colon, usually the latter, and we believe that these membranes are formed as the result of bowel effort in attempting to pass its contents through a more-or-less chronically contracted distal portion. We furthermore believe that the binding together of the ascending and transverse colon in a position of sharp angulation at the hepatic flexure is due to a combination of trauma (slight to be sure) of faecal masses plus a low-grade inflammation due to stasis. In addition to the deforming membranes at this point we frequently encounter enlarged mesenteric glands.

Many of these patients, particularly those between the ages of twenty and forty, come to operation because of upper abdominal symptoms due to pylorospasm, and as the trauma of operation in the right iliac fossa increases the spasm we have found that their immediate post-operative period has been made more comfortable by the administration of belladonna, bromides and alkalies for a few days preceding operation. With such preliminary treatment there has been much less upper abdominal distention with its accompanying nausea and vomiting.

A right paramedian incision retracting the right rectus muscle to the right has seemed on the whole most logical. To be sure, such an incision is

not directly over the part to be attacked but it can be enlarged in either direction without permanent damage to the abdominal musculature or its nerve supply. A moderately long incision may be necessary in order that the entire right colon and hepatic flexure may be inspected and appropriately treated. Here it may be said that a study of the X-ray pictures may be helpful in planning the incision. If the region of the hepatic flexure is above suspicion a low, moderately short incision is all that is necessary.

Upon opening the abdomen the terminal ileum is first inspected for Lane's bands which are sectioned if found. They will be found with relative frequency if routinely sought for. Next any pericolic membranes are pushed back after a few light touches with a scalpel. If the proper line of separation is found there will be no bleeding. Jackson's membranes are not disturbed unless they have extended across and are constricting the ascending colon or have produced a fixed angulation at the hepatic flexure. In either of these events the greatest gentleness is exercised in separating them, great care being taken to find, if possible, a natural line of separation. As has been said earlier we look upon these as being in part at least inflammatory and consequently likely to be reformed in contradistinction to the pericolic membranes which are congenital and show no tendency to recur. Finally the appendix is removed and the wound closed without drainage.

Upon return to bed these patients are given a small enema containing 60 grains of sodium bromide and 10 grains of chloral hydrate. This has been in use but a short time but the results have been satisfactory and encouraging. Operative trauma increases the preëxisting pylorospasm and gastric distention results. It is well known that morphine is of little value in controlling pylorospasm and thus the use of bromides by rectum. A fairly prompt return to a full laxative diet, aided where necessary by mild laxatives, practically completes the picture. Our greatest trouble has been that when these patients return home they are filled with milk and eggs, become constipated and lose their appetites. A proper diet and proper exercise will almost invariably correct this.

One of the most striking changes is rapid increase in weight but there are a few patients markedly underweight and with an enteroptosis who will need treatment for this condition. This number, however, will be small. There is also a small group, usually in the fourth and fifth decades, who have suffered severely with pylorospasm and constipation for long periods who at times of mental stress and fatigue will have a return of symptoms. This tendency seldom persists for more than six months and responds promptly to sedatives and alkalies as mentioned earlier in the paper.

In concluding, we make the plea that pericolic membranes be thought of when one is tempted to make the diagnosis of chronic appendicitis in the adolescents and that they be thought of in those beyond the second decade presenting atypical symptoms suggesting gastric or duodenal ulcers. Is it possible that this iliac fossa irriation which so definitely and distinctly produces pylorospasm with its accompanying hyperacidity may be an etiological factor in gastric or duodenal ulcer?

THE KERR TECHNIC IN RESECTIONS OF THE COLON*

BY JOHN H. GIBBON, M.D.

OF PHILADELPHIA, PA.

THE operation of intestinal resection probably has more names attached to it, indicating individual, if not original methods, than any other operation in the whole field of surgery. The paramount obstacle to success is infection, the dangers of which increase as one advances toward the rectum, and for decades the endeavor of surgeons has been to obviate this risk.

The popularizing of the two- and sometimes three-stage method of colonic resection (especially of the transverse and descending colon and sigmoid) about thirty years ago marks one of the great advances in abdominal surgery. The name of Mikulicz is irrevocably but erroneously attached to this operation, though through no act of his own. It was first suggested by Block in 1892, but probably first practised and published by Paul, of Liverpool, in 1895. Moynihan says that in France Hartmann is given the credit "by those afflicted with the quaint Gallic frugality of recognition of the work of others." In spite of the greatly lowered mortality following the two-stage operation, scores of new methods of resection and immediate anastomosis continued to appear, usually with the title of "aseptic." Many of these were appealing, and disliking the Paul-Mikulicz operation, for obvious reasons, I employed a number of them. In 1921 I did my last Paul-Mikulicz operation.

In 1923, Harry Kerr (*Journal of the American Medical Association*, vol. lxxxii, p. 641) of Washington, D. C., described what he called the "basting-stitch" technic which seemed to me much simpler and more nearly approaching an aseptic operation than any of those which I had tried. I used it in my next case (April 25, 1924) and since then in every case of anastomosis where I thought it applicable. The accompanying table shows what the results have been.

At the last meeting of the American Surgical Association in San Francisco, Kerr showed a moving picture of the technic as applied in resection of the cæcum and the following quotation is from his text (*ANNALS OF SURGERY*, October, 1930):

"A pair of crushing clamps is applied at right angles to the bowel axis in as close approximation as possible. One pair on the ileum; one pair on the transverse colon. The bowel is divided between each pair of clamps by the cautery which destroys any tissue remaining between the crushed clamps. The basting stitch is now applied. A stout linen suture is used in a curved round needle. The basting stitch consists essentially of a continuous suture, without knots, to temporarily close the intestinal incision, a separate suture be-

* Read before the conjoined meeting of the New York Surgical Society and the Philadelphia Academy of Surgery, February 10, 1932.

RESECTIONS OF THE COLON

TABLE OF CASES

NAME AGE HOSP. DATE	DIAGNOSIS	OPERATION	WOUND INFEC.	FECAL LEAK	OPERATIVE DEATHS	SUBSEQUENT DEATHS	RESULTS
1. R. H. 40 JEFF. HOSP. 4/31/21.	DIVERTICULITIS DESCENDING COLON AND SIGMOID.	RESECTION (SHOEMAKER) NO CECOSTOMY	YES	YES			REMAINS WELL
2. M. S. 40 PENN. HOSP. 5/2/23.	TUBERCULOSIS OF CECUM AND MECKEL'S DIVER- TICULUM.	RESECTION CECUM " " DIVER- TICULUM		SLIGHT			REMAINS WELL
3. G. A. S. 53 PENN. HOSP. 1/2/24.	CARCINOMA OF SIGMOID.	RESECTION (COLLINS) PRELIM. CECOSTOMY.	YES	YES	7th DAY FROM LOCAL INFECTION		
4. E. S. G. 51 PENN. HOSP. 4/25/24.	CARCINOMA OF SIGMOID	RESECTION (KERR) NO CECOST. RECTAL TUBE ABOVE ANASTO- MOSIS.	YES	NO			REMAINS WELL
5. J. E. P. 54 PENN. HOSP. 6/13/24.	CARCINOMA OF CECUM AND AS- CENDING COLON	RESECTION (KERR)	NO	NO			REMAINS WELL
6. MRS. K. 70 JEFF. HOSP. 12/1/24.	CARCINOMA OF HEPATIC FLEXURE LIVER AND STOMACH.	RESECTION OF CECUM ASCENDING AND TRANS. COLON - ALSO GALL BLADDER PORTIONS STOMACH AND LIVER (KERR)			24 HRS. FROM SHOCK		
7. MRS. B. 59 BRYN MAWR HOSP. 1/11/26.	CARCINOMA OF SIGMOID	RESECTION (KERR) NO CECOSTOMY	YES	YES			REMAINS WELL
8. MRS. S. 46 JEFF. HOSP. 5/11/26.	CARCINOMA OF CECUM AND AS- CENDING COLON. PERITONEAL ME- TASTASIS.	RESECTION (KERR)	NO	NO		DIED 4 MOS. AFTER OPERATION.	
9. W. H. S. 39 PENN. HOSP. 10/25/26.	TUBERCULOSIS OF CECUM AND ILEUM	RESECTION (KERR)	NO	NO			REMAINS WELL
10. A. M. 67 PENN. HOSP. 11/24/26.	CARCINOMA OF TRANS. COLON AND SIGMOID.	RESECTION (KERR) NO CECOSTOMY	NO	NO			REMAINS WELL
11. J. B. Mc C. 32 JEFF. HOSP. 2/12/28.	CARCINOMA OF DESCENDING COLON.	RESECTION (KERR) NO CECOSTOMY	NO	NO			REMAINS WELL
12. DR. T. 71 PENN. HOSP. 10/22/28.	CARCINOMA OF TRANS. & DESCEND COLON, LUES LOCOMOTOR ATAXIA	RESECTION AND SUTURE (NOT KERR) COLOSTOMY	YES	?	12th DAY IN- FECTION. NO PERITONITIS.		
13. D. P. 61 PENN. HOSP. 11/16/28	CARCINOMA OF SIGMOID	RESECTION (KERR) NO CECOSTOMY	YES		7th DAY PERITONITIS ABDOMEN RE- OPENED AND DRAINED 4th DAY.		
14. MRS. B. 62 JEFF. HOSP. 3/19/29.	CARCINOMA OF TRANS. COLON	RESECTION (KERR) PRELIM. CECOSTOMY & NUMEROUS TRANS- FUSIONS.		YES			REMAINS WELL POST-OPER. SUPPURATIVE PAROTIDITIS
15. MISS H. 54 PENN. HOSP. 3/10/29.	CARCINOMA OF SIGMOID MALIGNANT CYST OF L. OVARY. NO CONTACT BETWEEN LESIONS. PERITO- NEAL METASTASIS. OVARIOCTOMY 2/20/29.	RESECTION (KERR) PRELIM. CECOSTOMY.		YES		REOPERATED UPON 4/7/31 FOR MALIGN- ANT CYST RIGHT OVARY. RECURRENCE AT SITE OF RESECTION. DIED 2 YRS. AND 1 MO. AFTER RESEC- TION.	
16. A. A. S. 67 BRYN MAWR HOSP. 5/16/29.	CARCINOMA OF SIGMOID	RESECTION AND CECOSTOMY (KERR)	NO	NO			REMAINS WELL
17. MRS. M. 67 PENN. HOSP. 9/23/29.	CARCINOMA OF DESCEND. COLON METASTASIS TO LIVER.	RESECTION (KERR) PRELIM. CECOST. FOR AC. OBSTRUCTION	NO	NO		DIED HEPATIC METASTASIS 1 YR. & 3 MOS. AFTER RESEC- TION.	
18. E. F. 55 PENN. HOSP. 1/5/30.	CARCINOMA OF CECUM	RESECTION (KERR)	NO	NO			LIVING BUT HAS RECUR- RENCE.
19. P. O. 59 JEFF. HOSP. 2/4/30.	CARCINOMA OF CECUM.	RESECTION (KERR)	NO	NO	SUDDENLY ON 4th DAY. AU- TOPSY SHOW- ED NO LEAK OR PERITONI- TIS.		
20. MRS. Mc C. 58 PENN. HOSP. 7/1/30.	CARCINOMA OF DESCEND. COLON	RESECTION (KERR) CECOST. PRELIM. ILEO- SIGMOIDOSTOMY, DONE ELSEWHERE FOR OB- STRUCTION.	NO	NO			REMAINS WELL

ing used for each of the bowel ends. On account of their method of application and temporary purpose they serve, they bear a certain likeness to the 'basting' stitches of the seamstress, and for convenience we have called them by that name. The first and last bites of the basting stitch are placed parallel to the axis of the bowel.

"The intervening bites are placed parallel to the crushing clamp *across* the axis of the bowel with the loops between the stitches crossing over the clamps. The crushing clamps are withdrawn from beneath the loops of the basting stitches. The basting stitches are then drawn taut, invaginating the complete bowel circumference, and producing peritonization of the entire stoma. The mesenteric defect is obliterated by this invagination.

"The closed bowel ends to be anastomosed are swung on their respective basting stitches in apposition, ready for suture. A single anastomosing suture is all that is necessary. Single O chromic catgut is used on an eyeglass needle. When the anastomosis has been completed, the basting stitches are cut close to the bowel, one at the mesenteric border, and the other at the free border. The basting stitches are withdrawn. The bowel wall is then invaginated through the stoma to break up the agglutination caused by the crushing clamps and cautery."

To add anything to this simple and satisfactory technic would seem impossible, but in giving my experience with it, it would seem only right to mention any variations which have been practised. In the first place I have lacked the assurance to depend on a single continuous suture, and with one or two exceptions have always used a second. In nearly all of the cases here reported the smallest Payr clamp has been used for crushing and although it makes a wider diaphragm it has seemed to lessen the possibility of leakage during the subsequent steps of the operation, and as none of my recorded cases has had any functional trouble, the wider band of bowel inverted would seem a theoretic rather than an actual objection. One point which Kerr has emphasized and which is important is the placing of the clamps at such an angle on the bowel as to make the resulting stoma of larger calibre than the normal bowel. This is very important in resections of the small intestine. In one case the linen thread used for invagination broke and I had some difficulty in removing it, since when I have used flexible silk-worm gut.

Spinal anæsthesia has greatly facilitated the performance of the operation in our recent cases.

In the cases of resection of the cæcum here reported the end-to-side method was used and in none was a preliminary or accompanying ileostomy done.

I would not advise a colon anastomosis without preliminary or accompanying cæcostomy. The preliminary cæcostomy is always indicated where there is an acute obstruction or where there has been enough obstruction of the chronic type to cause distention and œdema of the bowel proximal to the lesion. Probably every surgeon has regretted yielding to the temptation to

do an immediate resection and anastomosis in these types. The bowel wall is teeming with bacteria and its circulation is poor. It will be seen in the table that I have done five resections without a cæcostomy. One of these cases died of peritonitis and I have the feeling that he might have lived had I done a cæcostomy; the others recovered. All of the cæcostomies, in the patients who lived, have closed spontaneously.

There were three resections done in the presence of metastasis (Cases VIII, XV, and XVII). In Case VIII, because of the multiple lesions in the colon, I thought they might be tuberculous and disregarded the peritoneal metastasis. In Case XV resection was necessitated by obstruction and was done in spite of peritoneal extensions from a malignant ovarian cyst. In Case XVII resection was done in order to avoid an artificial anus, in spite of a malignant nodule in the liver.

The operative deaths in the whole group (twenty cases) were five. Two of these, however, can hardly be attributed to the type of colon resection employed. One patient died suddenly on the fourth day and the autopsy revealed no peritonitis or leakage. In the other not only was the colon resected, but also a portion of the gastric wall and quite a block of the liver with the gall-bladder; this patient died of shock. There were three late deaths. Eleven of the twenty patients are living and well and one is living but has a recurrence.

Seventeen operations were done for carcinoma and among them occurred the five operative deaths. Three died subsequently: One at four months, one at fifteen months and one at twenty-five months, but all had metastasis at the time of resection. Eight patients in this group are well from eight years to eighteen months after operation. One is living, but has a recurrence.

Two of the remaining three patients had tuberculosis of the cæcum and one an extensive diverticulitis of the colon—all three remain well.

A glance at the table of cases will show that there are four in which the Kerr technic was not used. My reason for including them was that I wished to report all colon resections since I had ceased to do the Paul-Mikulicz operation. If we exclude these four cases the results in the remaining sixteen (Kerr) are somewhat better. In these sixteen cases there were three operative deaths. In the three subsequent deaths, all of which occurred in this group, metastasis was present at the time of operation. The patient now living but with a recurrence belongs in the Kerr group. The remaining nine of these sixteen patients are well at the present time.

If one is warranted in drawing conclusions from so small a number of cases, it would seem that the "basting-stitch" method of Kerr can replace the Paul-Mikulicz operation without increasing the mortality rate and with better ultimate results. Its greatest advantage to my mind is that one does a much wider resection of the bowel and mesentery than is often possible in the other type of operation.

The results in this series of cases tend to confirm the impression that cancer of the colon, if resected before metastasis has occurred, offers an ex-

cellent chance of cure. All of the patients in this group who recovered from the operation and who did not have demonstrable metastasis at the time, have with one exception, remained well from eighteen months to eight years. One of the cases of cancer of the sigmoid was in a man of thirty-two years and he has remained well four years.

DISCUSSION.—DR. FREDERICK W. BANCROFT (New York) said that if we are to be successful in eradicating cancer it must be by anatomical excision along lymphatic and vascular planes, and assuredly this is more safely carried out by resection as he has described. Where there is an obstruction or partial obstruction and we have satisfactory pre-operative localization by means of the barium enema, which is always to be advised rather than barium by mouth, a two-stage operation is the safest procedure. Where the growth is in the transverse, descending colon or sigmoid, a preliminary cæcostomy, as a decompressing procedure, through a McBurney incision, with no abdominal exploration, is a very advisable procedure. Any exploration at that time in a poor operative risk increases the mortality and may complicate the subsequent operation. Fortunately cancer of the cæcum or ascending colon is not apt to be obstructive, for in this region a primary cæcostomy would interfere with the later excision of the growth. If a two-stage operation is advisable, a preliminary ileocæcostomy may be done with resection at the second stage.

Kerr's method of the basting stitch is simple, does not need any pre-operative clamps and for this reason has the advantage over the Rankin method with his individual clamp. Kerr's advice to cut across the bowel obliquely is an excellent procedure in that it offers better circulation for the suture line and tends to prevent diminution of the size of the lumen. Doctor Bancroft exhibited an instrument that he has used at the Fifth Avenue Hospital for intestinal resections, which in his hands has proven very satisfactory; the von Petz clamp which resembles a Payr crushing clamp but also has a mechanism for inserting a double layer of staples across the bowel. When these staples have been inserted the bowel can be cut across between the two lines, with either a carbolized knife or a cautery, which prevents spilling and makes a relatively aseptic procedure. The line of staples can be rapidly whipped over with an ordinary inverting suture. This method is particularly applicable where one wishes to make a lateral anastomosis. It is also applicable in carcinoma of the rectosigmoid in the combined abdominal-peritoneal operation. The proximal end may be brought up through a left McBurney incision for a colostomy and the layer of staples excised when opening the colostomy. This procedure should diminish the risk of peritoneal soiling. X-rays taken post-operatively show that these staples persist *in situ* for a considerable period of time and are gradually extruded. In a recent case autopsied six months after an operation wherein a recurrence had taken place in the liver, the post-mortem examination showed that there was no foreign body reaction about a staple which still remained in the intestinal wall.

TRANSACTIONS

OF THE

NEW YORK SURGICAL SOCIETY

STATED MEETING HELD JANUARY 27, 1932

The President, DR. JOHN DOUGLAS, in the Chair

RECURRING INTESTINAL OBSTRUCTION FROM GALL-STONES

DR. CONDUCT W. CUTLER, JR., presented a woman, sixty-three years of age, who had been admitted to the Medical Division of the Roosevelt Hospital in January, 1931, three and one-half months before her entry upon the surgical service. At her original admission, she gave a history of pain in the upper abdomen, periodically, for the previous two years. This pain had been increasingly severe in the preceding two days, coming on after meals and radiating to the back and shoulders, associated with eructations but no vomiting. There had been some loss of appetite and constipation. No jaundice. The patient had lost fifteen pounds in weight. At that time, she showed some abdominal distension and while under investigation began to complain of pain in the lower abdomen, cramps, obstipation and tenesmus. For a time her condition suggested incomplete obstruction.

A rectal examination being done, a large faceted gall-stone was discovered in the rectum. This was removed with some difficulty, and the patient was immediately relieved. She returned home for three and one-half months, and was quite well, although still complaining of occasional fullness in the epigastrium, with a sense of soreness between the shoulder blades. On the day before her recent admission, she was suddenly seized with abdominal cramps and sharp pain in the epigastrium, radiating to the back. She was nauseated and vomited and abdominal cramps succeeded, increasing in frequency and in severity. Vomiting became more persistent and the vomitus assumed a fecal character. The abdomen had become distended and the bowels had not moved.

When admitted there was marked distension with visible peristalsis, the picture being distinctly one of acute intestinal obstruction. Immediate operation was performed. A distended loop of small intestine (lower ileum) was followed into the pelvis, at which point a large faceted gall-stone was discovered, impacted in the ileum. An enterotomy was done, the gall-stone removed and enterostomy tube introduced through the opening in the gut. This drained profusely, and she proceeded to a satisfactory and uncomplicated recovery. Her enterostomy tube was removed on the eighth day. The patient has been well since that time.

DR. CARL EGGERS said that one might speculate on how and where the gall-stones in these cases enter the alimentary tract. Do they pass through the cystic duct into the common duct and then by gradual dilatation of the papilla into the duodenum, or do they perforate through the gall-bladder wall directly into an adjoining portion of gut?

In the former case a long period of jaundice would probably precede the passage of the stone, while in the latter there need be no serious interference with function.

He has seen several patients with intestinal obstruction due to a large gall-stone, in none of whom was there any evidence of how the stone entered the

gut. He has, however, made an observation on the operating table in three cases which indicates that in two of these perforation into the duodenum was taking place, while in a third the colon was adherent over a large stone.

CASE I.—A lad of sixty-two years, who for years had had upper abdominal symptoms suggestive of gall-bladder disease, was operated on May 23, 1930, for a large ovarian cyst. After removing the cyst the gall-bladder was palpated and exposed. It contained one large calculus, apparently completely filling it. The pyloric end of the stomach and the duodenum were firmly adherent over it. It looked as if there were impending perforation. Nothing was done and the stone has not passed so far.

CASE II.—A woman, fifty-three years of age, was operated on for gall-bladder disease April 27, 1931. Röntgenologically she was a "no shadow" case. A mass of adhesions was found to occupy the region below the liver and to involve the distal end of the stomach as well as the duodenum and the omentum. Under great difficulty the gall-bladder was entered, and a large stone, one and a half inches in diameter, removed. It was firmly wedged in. As soon as it was removed there was a gush of fluid which looked like stomach contents. Examination showed it to come from the duodenum; they were dealing with a cholecystoduodenostomy, spontaneously produced, and no doubt in time the stone would have passed down into the duodenum.

CASE III.—An unmarried woman, forty-four years of age, was operated on for obstructive jaundice January 25, 1932. The gall-bladder contained four large stones, completely filling it. Over the lowest one at the fundus the colon had become firmly adherent. While carefully separating the two viscera the wall of each was found to be very thin and when the gut was completely freed it contained a perforation. Section of a fragment of this gut showed the mucous membrane to be destroyed over a wide area and replaced by exuberant granulation tissue richly infiltrated with inflammatory cells of various kinds, including numerous polymorphonuclear leucocytes. In this case evidently the gall-bladder would have perforated into the colon, allowing the stone to pass through into this part of the gut.

AGRANULOCYTOSIS ASSOCIATED WITH PERI-ANAL PHLEGMON

DOCTOR CUTLER presented a man sixty-one years of age. For two or three months preceding admission, the patient had not felt well. He had lost appetite and had lost some weight. For a number of years, he had noticed a nodule at the left side of the anus, which at times became somewhat swollen and painful. One week before admission, there was a recurrence of this pain and a swollen, tender area developed there. For the week preceding admission, he had had no bowel movement, complained of headache and increasing abdominal distension and discomfort. He had had no infectious disease in his past history. An initial lesion had been treated forty-five years ago. A Wassermann three years ago was negative. Patient had been a very heavy smoker, used alcohol in moderation. For the past year he had had slight dyspnoea on exertion. The patient's appearance was that of an exceedingly ill man, pale and undernourished. The abdomen was quite distended, with tympany throughout. There were no signs of tenderness or muscular rigidity and no masses were felt. The heart was somewhat enlarged but without adventitious sounds and with normal rhythm and rate. The lungs were clear. At the left side of the anus was a swollen, tender, reddened, fluctuant mass, the superficial area of which was necrotic. Patient's temperature upon admission was 102. His blood count showed hæmoglobin, 60 per cent.; red cells, 3,000,000; white cells, 450; polymorphonuclears, 18 per cent.; lymphocytes, 82 per cent.

Shortly after admission, the ischiorectal abscess was opened, and drained a quantity of pus. The patient's temperature began to subside somewhat but he was still exceedingly weak and ill. Attempts at emptying bowel by colonic irrigations were moderately successful, and gastric lavage was resorted to to control a persistent vomiting. Check-up

AGRANULOCYTOSIS ASSOCIATED WITH PERI-ANAL PHLEGMON

blood count was made to verify the extraordinary blood-picture and found to be essentially the same. On the fourth day after admission, his condition having shown relatively little improvement, a transfusion of 500 cubic centimetres of whole blood was made, following which some improvement in the blood-picture occurred, with almost immediate improvement in the patient's general condition. The vomiting had ceased and the distension became less marked and enemas were increasingly effective. The blood count gradually rose from 2,000 white cells, with 67 per cent. polymorphonuclears, on the second day after transfusion, to reach on the eleventh day after transfusion 10,000 white cells, with 89 per cent. polymorphonuclears. There was a consistent improvement during this period in the patient's condition and the peri-anal abscess completely healed.

Careful X-ray investigation of the intestinal tract showed no evidence of lesion. The urine showed nothing significant, beyond a little albumen and a few hyalin granular casts. Wassermann was negative. No growth was obtained on blood culture.

The patient was discharged in much improved condition and has subsequently been entirely comfortable, gaining in weight and strength.

Agranulocytosis was first described in 1922 by Schultz. Age 30 to 50 plus. Women 5 to men 1. Lesion usually throat or mouth. Frequently ulcerations in digestive tract as well. Cause.—Specific organism, endocrine or allergy? Symptoms.—Fever, headache, chill at onset. May follow period of general malaise. Local gangrenous lesion: 1 mouth, 2 vagina, 3 anus. Course.—Usually progressive to fatality. Treatment.—Transfusion. X-ray of bones.

DR. KIRBY DWIGHT said that the condition of agranulocytosis is more of a medical problem than a surgical one. Most of the studies on it have been made by medical men and it comes more into their field. But these cases are all the time getting into surgical wards because they have local lesions of a surgical nature, and frequently because the diagnosis of intestinal obstruction is made. The speaker first became interested in the subject two years ago at the Lincoln Hospital when a patient, a woman of middle age, was brought in with chills and fever and vomiting. She was placed in the surgical ward with a diagnosis of acute obstruction. That was soon changed and the diagnosis made of influenza, then typhoid fever, then septicæmia. The correct diagnosis of agranulocytosis was not made until the day of her death, and then by a medical man in consultation. The blood count at first was not suggestive; 11,000 leucocytes, 78 per cent. polymorphonuclears, but that went down on the day of her death, when she had a blood-picture of 5,000 leucocytes and no polymorphonuclears whatsoever. The previous history was of four somewhat similar attacks over a number of years, during two of which she was hospitalized, the diagnosis of agranulocytosis being made once at Bellevue. Autopsy showed ulcerations of the pharynx and base of the tongue, and marked œdema and induration around the lower rectum with a gangrenous area six centimetres in diameter. The nature of agranulocytosis is still in dispute as to whether it is a clinical entity or a constitutional condition. The former has been exploded by the wide variety of organisms found in the blood, all the way from *Staphylococcus aureus* to colon bacilli. The general opinion is that it is a disorder of the leucopoietic system whereby the patient is unable to work up resistance to infection in times of stress; where the blood count of the patient should go up it lies down under assault. At Johns Hopkins they have been following

these developments in the case of a boy who has had ten or fifteen attacks. They have studied his blood-picture before the attacks and found that a fall in polymorphonuclears precedes the onset of the symptoms of the infection, and rises to normal before the infection has subsided.

DR. EDWARD D. TRUESDELL reported a case of agranulocytic angina coming under his care in 1923. This was an unmarried woman of forty-three years who had complained of severe pain in the rectum for three weeks. Six months before her tonsils had been removed and the tonsillar fossæ had remained unhealed. The Wassermann was negative; blood culture sterile; there were no Vincent's organisms in the throat; the white blood-cells 11,000; 80 and 20. No special morphology of the white cells was noted or particularly looked for. Her pain persisting and evidently severe, the anal sphincter was dilated under anæsthesia and a careful search for pathology in this region was made, but without results. Her temperature persisted, being between 102° and 104°. A phlegmon developed about the rectum which promptly broke down, and, sloughing rapidly, extended beyond the reach of the examining finger, until the death of the patient.

There was no autopsy and the case was closed under the diagnosis of "hæmorrhoids and sepsis." The patient had been seen by various consultants and specialists. None of these could explain the condition, although one contributed the helpful comment that "this woman is evidently suffering from a disease we know little or nothing about." However, the articles by Lovett, in the *Journal of the American Medical Association* in 1924, and Piette, in the same periodical in 1925, are so precisely applicable to this patient's ailment that there is no doubt but what this was a case of agranulocytosis. It is of interest to observe that this condition, recognized fairly promptly and generally today, was practically unknown and unclassified ten years ago, even if still not satisfactorily explained.

PRIMARY PLASTIC REPAIR OF CRUSHING INJURY OF THE THUMB

DOCTOR CUTLER presented a man who, shortly before admission to Roosevelt Hospital on March 18, 1930, while working on a fan belt, had his right hand caught in such a way as to crush the index finger and base of the thumb. He was brought immediately to the hospital, where, after a primary cleansing of the wound, ether anæsthesia was administered and débridement done. The index finger was held in place only by a shred of skin and its amputation was inevitable. Fragments of bone representing the head of the second metacarpal were removed and the bone end rounded off. The base of the thumb was also crushed and the thumb itself lacerated. It hung loosely by a segment of areolar tissue and skin on the palmar surface. One anterior digital vessel remained undamaged in this tissue. There was a compounding fracture of the base of the first phalanx and the head of the first metacarpal was comminuted into numerous fragments. Saving of the thumb seemed practically hopeless, yet recognizing the importance of that digit in subsequent usefulness of the hand, an attempt was made to save it, as follows:

The fragments of bone representing the base of the first phalanx and the head of the metacarpal were removed and the ends of both bones rounded off with a rongeur. This procedure shortened the metacarpal by about three-quarters of an inch. Interrupted sutures were now taken, approximating the lacerated capsule of the distal part of the joint to the periosteum of the stump of metacarpal. To reinforce this, several stitches were taken in the areolar tissue about the repair and the extensor and flexor tendons were sutured. Light closure of the superficial wound was now done with interrupted sutures of silk and a drain placed down to the region of the joint. The superficial wound of the hand was similarly repaired. It was hoped by this procedure to produce, if healing occurred, either a new joint at the injured area or an ankylosis between the metacarpal and the phalanx. Twenty-four hours after the operation, the thumb was quite cold and cyanotic. Two days later the color of the thumb was somewhat restored

CARCINOMA OF THE STOMACH AFTER OPERATION

and it was a trifle warmer. The nutrition of the thumb was apparently reëstablished and healing progressed in the presence of a moderate infection which caused a purulent discharge from several portions of the wound.

The man was discharged a month after his injury with some active and passive motion occurring at the reconstructed joint and with the discharging sinus leading down to that area. This discharge continued for about three months, at the end of which time the hand was completely healed, and the patient began to use it. The reconstruction proving definitely successful has enabled the patient to retain a moderate usefulness of his hand, at least to the extent of using tools and permitting him to resume work.

DR. HENRY H. M. LYLE said that one should be very conservative in treating injuries of the thumb, always keeping in mind that the thumb is the most important finger of the hand. Much can be done even if only a stump of the metacarpal bone is left. Doctor Lyle referred to several cases shown before this society in which useful thumbs have been constructed. Huguier, of Paris, performed this operation in 1852. His method and results were published in the *Arch. gén. de méd.*, vol. i, p. 78, 1874. Klapp, in 1912, described a similar procedure. Doctor Lyle performed a similar operation in January, 1913, the result of which was shown before this society (*ANNALS OF SURGERY*, vol. lix, p. 767, May, 1914, and *ANNALS OF SURGERY*, vol. lxxvi, p. 124). It was described at that time as Klapp's method. Further research of the literature, however, showed that the credit was due to Huguier.

CARCINOMA OF THE STOMACH SEVEN YEARS, NINE MONTHS AFTER OPERATION

DR. EDWARD W. PETERSON presented a man, seventy-one years of age. His father died at seventy years of age of uræmia; his mother at sixty years of "stomach trouble." Never seriously ill. Over a long period of years he has had numerous digestive upsets. In 1919 he was treated in a sanitarium for stomach ulcer. In 1923 he was operated upon for large hæmorrhoids which often prolapsed and bled. In 1924 he complained of attacks of indigestion with headaches, vertigo, nausea, diarrhœa and weakness. Although always very thin he was gradually losing weight. Examination of urine and fæces showed nothing of consequence. Stomach contents showed no free hydrochloric acid, total acidity 15, lactic acid present, numerous yeast and occasional red blood-cells.

A radiographical study of the gastro-intestinal tract made May 23, 1924, resulted in a report that there was a carcinoma involving the pars-pylorica of the stomach. The tumor was centrally located and was infiltrated in the wall a short distance above the pylorus. There was a moderate degree of gastric retention and intestinal hypermotility.

The patient was operated upon at the Post-Graduate Hospital May 27, 1924, and the findings were as follow: (1) A hard pyloric tumor of medium size, with many metastatic glands in the mesentery in the vicinity of the growth; (2) a gall-bladder packed with stones; and a large kinked appendix. A wide resection of the stomach was done, with a Billroth II posterior gastrojejunostomy. An attempt was made, too, to remove the gland-bearing tissue nearby. Also the gall-bladder and appendix were removed.

The laboratory examination of the removed portion of stomach showed on the anterior wall a large fungoid mass measuring fifty by fifty-five millimetres in diameter with an ulcerated surface. In the large omentum there was a lymph-gland measuring eighteen by eight millimetres and several smaller harder nodules. Sections of the tumor warranted a diagnosis of adeno-carcinoma of the stomach with metastasis in the lymph-glands. Chronic cholecystitis. Chronic appendicitis.

The patient stood the operation remarkably well and for the first four or five days following his condition was good. Then it was noted that the dressing was saturated and an examination of the wound showed a profuse escape of digestive fluids. This continued for over two weeks, when the discharge gradually lessened, finally stopped, and the wound then closed. During this time the abdominal wall about the incision was badly eroded by the action of the digestive juices. The stay in the hospital was about four weeks.

A short time later, there developed considerable pain in the upper abdomen. In the absence of Doctor Peterson, the late Doctor Silleck visited the patient at his home. He re-opened the old sinus and a considerable quantity of foul-smelling, dark fluid was evacuated. Rapid healing followed and there was no further accumulation of fluid and no more leakage.

Except when there are indiscretions as to diet or alcohol, the patient's digestive apparatus functions very satisfactorily. He has had a number of stomach upsets, however. A recurrence of the malignancy was to be expected in this case, but it is nearly eight years now since the operation was performed. It is a matter for conjecture if the leakage and infection, so distressing at the time, could have had any beneficent effect in preventing a return of the malignancy.

DR. RICHARD LEWISOHN noted that age is no contra-indication to radical resection of the stomach. Most of these patients are around sixty years of age and they stand the operation remarkably well. There is another reason for radicalism in this type of carcinoma of the stomach and that is that in many instances it is impossible at the time of operation to be sure whether one is dealing with ulcer or carcinoma. Many years ago the speaker turned down a case as an inoperable carcinoma of the cardia and this man is well today, the lesion having evidently been an ulcer. That day a man was admitted to the speaker's service at Mount Sinai Hospital with a lipoma of the back who, six years ago on laparotomy, was pronounced inoperable because of a fixed carcinoma of the pyloric region. Nothing further was done to him at the time. He is well today, without any gastric symptoms. Radical cures of five years and over are very rare, but in view of the hopelessness of this condition and the failures that have followed X-ray and radium treatment, extreme radicalism is justified.

DR. JOHN A. MCCREERY remarked that it was well worth while to show a case of this sort if only to combat the general feeling of hopelessness regarding radical procedures in carcinoma of the stomach. In his experience, radical operation in cases on the borderline and over the borderline is worth while. He had one that had gone on for seven years and another for eleven years in which this operation was done with satisfactory results. In the eleven-year case operation was refused in two hospitals. Even if there is metastasis in the liver or glands the patient may get along with distinct comfort and economical improvement.

MESENTERIC CYSTS

DOCTOR PETERSON presented a woman, twenty-eight years of age, who was first seen by him in consultation with Dr. A. A. Weiss, of this city, April 10, 1930. Three or four days before she had complained of abdominal pain, which had localized in the right

ÆROPHAGIA

lower abdomen. The pain was not severe, but persistent. There was some nausea but no vomiting. Bowels, usually regular, were constipated. There was only slight elevation of temperature, the urine was negative, and a blood examination showed some increase in the total leucocytes and the percentage of polymorphonuclear cells. The patient had always considered herself an exceptionally healthy individual.

The physical examination was negative except for rather marked tenderness over McBurney's point, with some muscular spasm and resistance. In the course of the examination, however, a rounded freely movable, non-tender tumor mass was discovered, just to the right of and below the umbilicus. When questioned about it the patient said that she had known of its presence since she was sixteen years of age, but as it had never caused her any inconvenience whatever, it gave her no concern.

A diagnosis of acute appendicitis and cyst of the mesentery was made at this time. The patient entered the Post-Graduate Hospital that night and was operated upon early the following morning.

The abdomen was entered through a para-rectus (Kammerer) incision. The appendix was readily delivered and removed. The ileum was then pulled up and a tumor mass consisting of three mesenteric cysts, in the lower ileum, was delivered. These cysts were carefully enucleated from the mesentery, without any damage to the blood supply to the bowel. The openings in the mesentery were closed with plain catgut sutures. One of the cysts was opened during its removal. It was filled with thick sebaceous material. Although no hair or bone was discovered, the contents of the cyst looked typical of the usual material found in dermoid cysts.

Following operation the patient suffered considerable nausea, vomiting, and abdominal discomfort for two or three days, after which time she made an unusually smooth convalescence, and was able to leave the hospital on the ninth post-operative day. She has had no further digestive upsets and it is believed that her attacks might have been due to the diseased appendix. Her health has been perfect since the operation.

Sections of the wall of the opened cyst show a lining of necrotic material beneath which there is a zone of epithelioid cells containing occasional poorly defined multinucleated giant cells and intermingled with lymphocytes. External to this there is a layer of fibrous tissue containing abundant lymphocytes and at one place a small nodule of epithelioid cells suggesting a small tubercle.

ÆROPHAGIA

DR. FRANK S. MATHEWS presented a woman who first applied for treatment at St. Luke's Hospital four years ago. At that time the cribbing was loud and continued through practically all her waking hours. Her employers had had to assign her a position which did not bring her in contact with the public. She did not seem neurotic, had four children and was the family breadwinner. Examination revealed no cause for the complaint. One year ago she returned for treatment with the story that the cribbing had continued, that shortly after her previous examination there was added upper abdominal distress and recently a few sharp attacks of pain suggesting gall-stones. A plain plate of the abdomen showed a long gall-bladder protruding far below the liver margin and containing a number of ring-like shadows of gall-stones. At the head of the pancreas some small shadows suggested calcified nodes. At operation the gall-bladder was removed, there was a choledochotomy with exploration of the ducts and an appendectomy. One year has passed since the operation. The cribbing ceased immediately after operation and has not returned since. In several hundred gall-bladder cases, Doctor Mathews had never seen one in which ærophagia seemed to have depended upon gall-bladder disease.

DR. CARL EGGERS said he recently saw a patient with a history similar to that of Doctor Mathews' case. She was an unmarried woman, forty-four

years of age, who had not been well for the past four years. She had attacks of ærophagia associated with slight indigestion. The ærophagia became so persistent, and the eructations of gas so loud and annoying that she had lost her position on account of it. The attending physician considered the condition a neurosis and he did not suspect gall-bladder disease until the patient suddenly became jaundiced following an attack of pain about three months before she was seen by Doctors Eggers. A flat X-ray plate showed four large faceted stones in the gall-bladder. At operation there was found in addition to these a large common-duct stone the size and shape of an olive.

AVULSION OF THE BICEPS TENDON

DR. HENRY H. M. LYLE presented a man fifty years of age, a professional acrobat. Two years ago, while doing his turn on the swinging rings, he felt a sharp pain just below his left elbow, heard something snap and fell to the ground. The following morning he was admitted to St. Luke's Hospital where a diagnosis of rupture of the biceps was made. There was the typical gap in the tendon, the retraction of the muscle belly upward, ecchymosis and tenderness over the bicipital tuberosity of the radius. At operation the tendon was found to be sheered off at its insertion. The operative problem was the attachment of the tendon to the bone as the periosteum had been stripped off. Two braided silk sutures were woven into the tendon, the free ends emerging from the fractured end of the tendon; the free ends of the suture were then passed around the bone and fastened by a timber hitch with a double tie. This tie was demonstrated before the Surgical Society in a case of fixation of fractures of both bones of the arm by the late Dr. Charles Dowd. Even on a smooth polished surface this knot will not slip.

Within one month and a half he began light work and at the end of three months he took up his act again.

DR. SEWARD ERDMAN said he had a similar case five years ago but it was not as severe because there was no rupture of the tendon but of the muscle. The patient was a lad nineteen years of age who, while playing football, made a flying tackle; he reached forward with his right hand and grabbed the runner's ankle and held on, the force of the sudden wrench tearing the inner half of the muscular portion of the biceps where it enters the lower tendon of insertion. He was treated for "Charley Horse." Doctor Erdman saw him at Christmas vacation six weeks after the injury. There was visible a lump on the inner aspect of the biceps which slipped up and down on flexion and extension of the elbow. The biceps function was weak and operation was done to repair the torn muscle. At operation, the retracted proximal stump of the torn inner half of the muscle was found to have become smooth and conical and slightly fibrosed.

During motion at the elbow, this idle muscle bundle slid up and down within its intact fascial sheath.

The muscle stump was freshened and rather readily drawn down and sutured to the tendon of insertion, and the convalescence was uneventful.

Four months later he pitched on a college baseball team, using the injured arm.

HYPOSPADIAS

DR. HENRY H. M. LYLE presented a boy six years of age. He said, "Surgeons often have been disappointed in the results of the ordinary plastic operations for the cure of hypospadias." His own results had never been satisfactory, consequently his enthusiasm for operating on hypospadias died out. He now presented a recent case in the hope of reviving flagging interest. It is a good functional and æsthetic result. Doctor Lyle called attention to the different stages in the operation: (1) The correction

KNEE-JOINT ARTHROTOMY

of the ventral curve of the penis; (2) the formation of the pouch and the passing of the pouch through the reflected foreskin, thus bringing the new urethra to the glans; (3) formation of the glandular portion of the urethra; (4) æsthetic touches. The strength of this operation lies in the formation of the pouch; here there is no opportunity for lateral leakage as there are no lateral sutures.

DR. FRANK S. MATHEWS expressed the opinion that when the urethra terminates at the base of the glans or close to it, that function is not sufficiently interfered with to make operation desirable. Matters are quite different when the hypospadias is complete as in Doctor Lyle's case. Many operations have been devised for the restoration of the urethra. In most of them failure comes from fistulas forming where sutures are inserted and are dependent on urine passing over the suture line. By the method which Doctor Lyle employed and in which his result is exceedingly good, there are no sutures on the floor of the newly constructed urethra and the result is a strong argument for the excellence of the operation selected and the execution of it.

EXCISION OF INTERNAL SEMILUNAR CARTILAGE

DR. JOHN H. GARLOCK presented a man, thirty-six years of age, first seen December 16, 1931.

October 14, 1931, he slipped off a wooden horse, striking his right knee and shin against its edge in such a way as to abduct the leg on the thigh. The knee swelled considerably. Was treated by baking and massage for two months. When seen by the speaker he complained of pain on the inner side of the knee, inability to walk on uneven surfaces, and the sensation of something moving around in the joint. There was no visible or palpable deformity of the knee. There was no effusion. There was marked tenderness along the anterior extremity of the internal semilunar cartilage. When the knee was abducted and adducted in the flexed position, pain was experienced in this same situation. He was operated upon December 29, 1931. A curved medial incision was made. The patella was retracted and the knee-joint exposed. The internal semilunar cartilage was found detached at its anterior extremity for a distance of about three-quarters of an inch. There was no sign of fracture of the meniscus. It was removed. The synovial membrane was considerably thickened and reddened. The external cartilage was found to be intact. There was no hypertrophy of the fat pad, and no evidence of any loose bodies. The wound was closed after careful hæmostasis, and a posterior splint applied. The latter was removed on the fourth day when active motion within the limits of pain was instituted. This was continued until the twelfth post-operative day, when the patient was allowed out of bed. He was discharged on the fifteenth post-operative day, walking with the aid of a cane. Since then he has been receiving physiotherapy. At the present time, there is normal extension and almost complete flexion, with a freely movable patella.

KNEE-JOINT ARTHROTOMY

DR. JOHN J. MOORHEAD read a paper with the above title for which see page 17.

In illustration of this paper Doctor Moorhead presented a woman, aged forty-three years, who had had both knees operated on at the Post-Graduate Hospital for hypertrophic osteoarthritis. The first medio-lateral arthrotomy was performed January 14, 1929. Prior thereto she had been on crutches eighteen months, dating the onset of her bilateral trouble to a fall from a ladder. At the operation bony spiculæ were removed from the articular margins of the femur and the tibia and a partial excision was made of a hypertrophic synovia. After the first operation she left the hospital on the tenth day.

The second operation was on February 10, 1930, and the findings were almost identical and at that time she was in the hospital three weeks and two days because she developed a phlebitis. Incidentally her uterus was removed for multiple fibroids in March, 1931.

At the present time she still has some swelling of the left leg as the result of the phlebitis, but her knee-joint motion is excellent.

SECOND PATIENT.—A man, aged forty years, was injured June 15, 1931, by a twist and a fall on the left knee. A very marked swelling followed which shortly after the accident was removed by aspiration. He was first seen by Doctor Moorhead on September 22, 1931. At that time he had a very marked synovitis with extension to 165° and flexion to 90° and a marked atrophy of the thigh and calf.

Examination showed an osteochondritis desiccans located in the typical position, namely, on the mesial side of the femoral condyle. He was operated on by the speaker at the Post-Graduate Hospital October 15, 1931, at which time a plaque of bone approximately one and one-quarter by three-quarters inches was removed, leaving an excavation on the under surface of the condyle about one-eighth of an inch deep. He remained ten days in the hospital. An office note under date of October 27 showed that he had primary union with flexion to 90° and extension to 170° , with still some swelling of the joint and atrophy of the adjacent muscles. At the present time he has full extension and flexion to about 110° . He is at work and his present disability is due to the remaining atrophy.

THIRD PATIENT.—A man, thirty years of age, fell December 26, 1930, and twisted his left knee. Thereafter the joint was swollen and disabled as the result of a synovitis. This resisted ordinary treatment and on February 12, under local anæsthesia at the Post-Graduate Hospital, sixty-five cubic centimetres of clear fluid were aspirated. At this time there was considerable pain and joint restriction. There was a reaccumulation of fluid and on April 1 a medio-lateral arthrotomy was done. The findings were a fracture dislocation of the internal semilunar with a hypertrophic synovitis and hypertrophy of the subpatella fat pads. The internal semilunar was excised together with part of the synovial lining of the upper pouches of the joint and of the tabs of subpatella fat. He was discharged from the hospital April 12.

August 1, 1931, he sustained an injury to the opposite knee due to a direct blow and thereafter there was a marked synovitis which also failed to respond to treatment. He was operated on October 21, 1931. The findings were hypertrophic synovitis with hypertrophy of the fat pads, with an intact semilunar. A partial synovectomy was done with the removal of the hypertrophied tabs. At the present time he has full extension and his flexion is to 120° .

DR. ARTHUR KRIDA (by invitation) expressed his belief that knee-joint operations of this type should in general be done more frequently than is at present the case. He had operated on over 150 cases. The nature of the cases differed perhaps somewhat from Doctor Moorhead's cases, which appeared to be mainly of traumatic origin. A considerable percentage of the speaker's cases were cases of rheumatoid arthritis, and it was amazing to him in observing this pathology at operation that anything short of operation could be expected to afford relief. On the other hand in his experience a great many crippled knees of this type can be salvaged by excision of the diseased synovial membrane.

Doctor Krida stated also that he had operated for the repair of torn crucial ligaments in ten cases with perfectly satisfactory results in eight. He emphasized the fact that operation on the knee-joint is safe, that the knee-

joint exhibits a remarkable resistance to infection and that in his series there were no major accidents.

DR. JOHN H. GARLOCK gave a short review of thirty-six cases operated on since 1924. There were thirty-four men and two women. The average age incidence was thirty-five years. Thirty cases presented injuries of the internal semilunar cartilage. There was one cyst of the external semilunar cartilage. Two patients presented thickened retropatellar fat pads. There were three instances of loose arthroliths. One patient presented extensive adhesions in the suprapatellar bursa following an old fracture of the femur with extension of the fracture line into the knee-joint. No synovectomies were performed. In two instances the Jones incision was used. In thirty-four cases the long antero-lateral incision, described by Doctor Moorhead, was used. The average stay in the hospital was fourteen days. Active motion was usually started on the fourth or fifth post-operative day. The patients were usually allowed out of bed on the twelfth day. The results were as follows:

In thirty-four cases there was return of full function. One patient presented about 30 per cent. impairment of flexion in the knee-joint. This patient was a luetic Negro who was operated upon for a torn semilunar cartilage. In the patient with a thickened retropatellar fat pad only a fair result was obtained. There were two subcutaneous hæmatomas and no infections.

The operative technic included the use of an Esmarch bandage, careful hæmostasis and an attempt to avoid trauma. No special effort was made to use the Lane technic. He said he has always felt it unnecessary to remove thickened synovial membrane in the presence of cartilage injuries; believing that following removal of the cartilage the evidences of irritation of the synovia would disappear. This seems to have been borne out by the end-results.

The speaker had not seen the need for Lane technic in operating upon the knee-joint, provided asepsis was rigidly controlled. He wondered why Doctor Moorhead had not carried further his analogy between the abdomen and the knee regarding operative technic. The abdomen seems to take care of mild contaminations and experience would seem to indicate that the knee-joint probably can do the same.

DR. HENRY H. M. LYLE referred to the case of a professional soccer player who had both internal semilunar cartilages removed in Scotland. He consulted Doctor Lyle for injury to the external semilunar cartilage of the right knee and wanted it taken out as he could not go on playing soccer. Doctor Lyle did not consider it wise to do this but yielded to the patient's insistence. This man is one of the stars in a local professional team and has played steadily for over two years although both semilunars have been removed from the right knee.

TRANSACTIONS OF THE PHILADELPHIA ACADEMY OF SURGERY AND THE NEW YORK SURGICAL SOCIETY

ANNUAL CONJOINT MEETING HELD AT PHILADELPHIA, FEBRUARY 10, 1932

DR. JOHN SPEESE, President of the Philadelphia Academy of Surgery,
in the Chair

CALVIN M. SMYTH, JR., M.D., Recorder

SPIROCHÆTAL (TREPONEMA VINCENTI) INFECTIONS OF HAND

DR. JOHN B. FLICK (Philadelphia) said the pathogenesis of the organisms commonly identified with "Plaut-Vincent's angina" apparently is widespread. In reviewing the literature one is impressed with the many reports of various lesions from which these organisms have been isolated. Among them may be mentioned vaginitis, middle-ear and mastoid disease, pulmonary abscess, bronchiectasis and wounds, particularly those made by the teeth of human beings.

The inciting cause of Plaut-Vincent's infection is universally believed to be a spirochæte associated with a fusiform bacillus, but other organisms are usually found in the lesions.

There is a difference of opinion regarding the relationship of the spirochæte and the fusiform bacillus. While many believe that a symbiosis is responsible for the diseased condition, others are of the opinion that the spirochæte is merely a highly differentiated form of the same microorganism. Tunncliffe¹ has carried out studies which tend to support the latter view. Topley and Wilson², however, say that the balance of evidence is definitely against the theory that the fusiform bacilli and spirilla are different forms in the life cycle of one organism. It has been pointed out by Tunncliffe and others that the spirochætes precede the fusiform bacilli in the invasion of tissues and it is thought that they are responsible for the extensive destruction which occurs.³

Hultgen, in 1910,⁴ reported what he believed to be the first case on record of a "gangrenous perionychia" due to the symbiosis of the fusiform bacillus and the spirochæta denticola:

The patient was a child of seven years brought to him because of an ill-smelling affection of her left hand which had existed for a week. On examination "the nail of the left index finger was found hanging to its bed by only a few shreds, covering a necrotic area which was surrounded by discolored pultaceous and extremely fetid tissue remnants. The upper half of the distal phalanx of the left index finger was destroyed, but the sphacelus was limited at the distal phalangeal joint by slightly irritated, reddish and moderately swollen tissues." There was similar but only slight involvement of the left thumb and slight left axillary adenitis. She had several carious teeth and her gums were not healthy. Microscopically, smears from the affected finger tips showed the fusiform bacillus and the spirochæta denticola as did preparations from the carious teeth. The girl was in the habit of biting her fingers and the etiological connection between her carious teeth and the gangrenous affection of the finger-nail beds, as Doctor Hultgen pointed out, is quite plain.

SPIROCHÆTAL (TREPONEMA VINCENTI) INFECTIONS OF HAND

Since 1910, a number of cases of Plaut-Vincent's infections of the fingers or hand have been reported in the literature, references to which are appended.^{5, 6, 7, 8, 9, 10, 11} Almost all of them have been due to wounds by the teeth of human beings. In 1929, Flick reported a case of gangrenous infection of the hand and forearm following a human bite of the thumb which resulted fatally.¹² Smears of the pus in this case showed spirochætes but not fusiform bacilli. There was extensive destruction of tissue in the hand and forearm and the odor was most offensive, reminding one of that which is given off in spirochætal pulmonary gangrene. Permission for amputation of the forearm was refused and the patient died sixteen days after receiving the injury.

He purposed now to report five additional cases of Plaut-Vincent's infection of the hand and to comment briefly on the disease.

CASE I. —A Negro man, aged thirty years (Pennsylvania Hospital, Out-patient Department, History No. 39,209), applied to the Pennsylvania Hospital January 20, 1930, for treatment of a human bite of his left middle finger which he had received that day. The wound, which was over the distal phalanx, was cauterized with phenol and a dressing applied. Upon his return to the hospital four days later the wound showed evidence of infection. Microscopical examination of smears of the pus showed many spirochætes and fusiform bacilli. Hot salt-solution dressings were applied and he was instructed to soak the finger daily in hot salt solution. On February 7 there was no longer any evidence of acute inflammation, but there was a bulbous enlargement of the distal phalanx and some œdema of the entire finger. An X-ray examination made at this time showed almost complete absorption of the distal phalanx, only the thin portion of the base and the ungual process remaining. The patient failed to return for observation and could not be traced.

CASE II. A Negro man, aged forty-five years (Pennsylvania Hospital, Unit History No. 16,729), applied to the Pennsylvania Hospital June 4, 1930, for treatment of a human bite of the right third finger and thumb and the left thumb, which he had received that day. The wounds were treated with iodine and a dry dressing applied. Three days later there was soreness in the right axilla. Six days after receiving the injuries the wound over the distal phalanx of the third finger was found to be necrotic and foul-smelling. In the Receiving Ward of the hospital, under nitrous-oxide anæsthesia, the finger was incised, necrotic tissue clipped away and hot salt-solution dressings applied. The patient was then admitted to the house for further treatment. Microscopical examination of smears of the pus showed suggestive spirilla forms and a moderate number of fusiform bacilli. In spite of treatment the infection progressed, there was marked sloughing of the soft tissues and a foul stench to the wound. On June 18, fourteen days after receiving the injury, Dr. Alan Parker disarticulated the distal phalanx. For a few days the infection seemed to be under control and then puffiness and fluctuation developed on the dorsum of the same finger lower down. This area was drained under local anæsthesia on June 27. Microscopical examination of smears made from the pus at this time showed fusiform bacilli only, the suggestive spirilla forms having disappeared. Hot salt-solution dressings were continued and the patient was discharged from the hospital July 14. He continued under observation as an out-patient until September 8, when his wounds were healed.

CASE III.—An Italian man, aged seventy years (Pennsylvania Hospital, Unit History No. 20,769), applied to the Pennsylvania Hospital March 17, 1931, for treatment of an infection on the dorsum of his right hand. Two days previous he had opened a small blister on the back of the hand with a pocket-knife with which he sometimes picked his teeth. He had a temperature of 99° F. Local treatment was given, he was

instructed to soak the hand in salt solution daily and referred to the Out-patient Department. On April 4 a microscopical examination of a smear made from the pus in his wound showed many spirochaetes and fusiform bacilli. After this arsphenamine dressings were applied daily. The condition became worse, the hand was incised and through-and-through drainage instituted. April 13, he was admitted to the house and examination showed a necrotic wound on the dorsum of the hand between the second and third metacarpal bones and a corresponding wound on the palm. Both wounds were discharging foul-smelling, greenish-yellow pus, the tissues about the wounds were discolored and the hand somewhat swollen. He had an evening temperature of 100.2° F. Examination of his mouth showed a marked infection of the gums and a number of infected stumps of teeth. April 17, a swelling on the dorsum of the right index finger was incised and pus obtained. April 27, the hand having become more swollen,



FIG 1—Case III. Rontgenogram of right hand which was made just prior to amputation. The destruction of bone and involvement of joints is evident.

the right index finger discolored and the proximal phalanx necrotic further surgical interference was decided upon. At operation the tendons to the index finger were found to be necrotic and the metacarpophalangeal joint of that finger destroyed. The finger was disarticulated. The incisions on the dorsum and palm of the hand were enlarged but no collection of pus was encountered. The hand was soaked daily in potassium permanganate solution and in addition continuous wet dressings were used. May 13, Dr. Adolph Walkling disarticulated the right third finger. Exposure to the rays of the sun was then tried. May 21, the patient was given 0.6 grams of neoarsphenamine intravenously. Other sinuses developed in the palm and on the dorsum of the hand. The swelling increased. It was evident that the remaining metacarpophalangeal joints were involved (Fig. 1) and permission for amputation was finally secured. May 24, amputation through the forearm eight centimetres above the wrist-joint was done. The skin was closed with clips, leaving in the wound a small rubber-covered gauze

drain. His temperature became normal the following day. The wound healed without infection and he was discharged from the hospital eight days after the amputation was done.

The pathological reports (Drs. George J. Righter and John T. Bauer) in this case are of interest and are herewith given.

"Three specimens were separately received for pathological examination, following successive operations—the index finger of the right hand (S. 16,433), the middle finger of the right hand (S. 16,495), and the remainder of the right hand amputated about

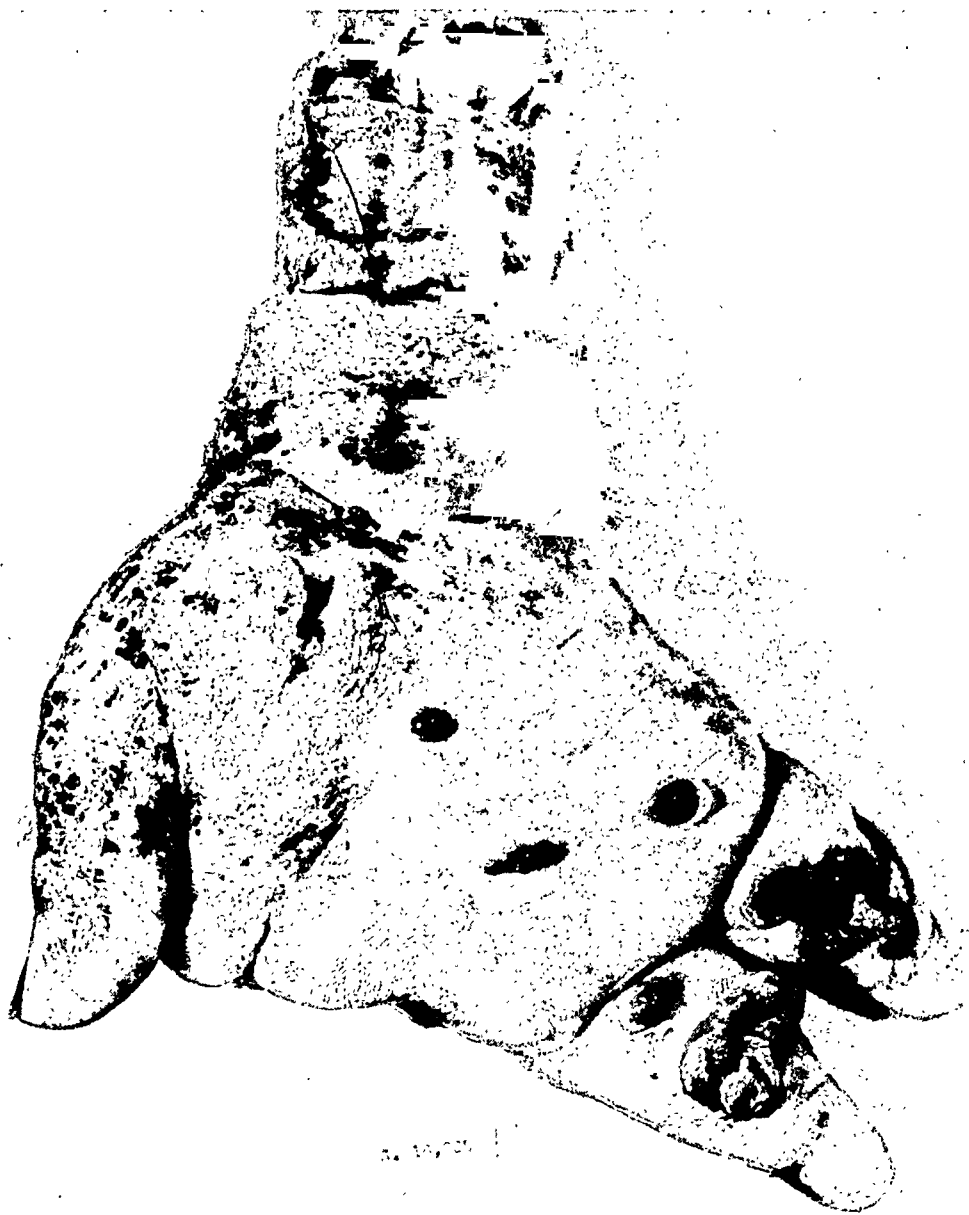


FIG. 2.—Case III. Photograph of right hand after amputation.

eight centimetres proximal to the wrist (S. 16,668). From these specimens approximately twenty-four blocks were chosen for microscopical study. As the pathological process was the same in each, differing only in extent, the combined description of the gross specimens and sections will be presented.

"On gross examination the hand and fingers were swollen greatly, the greatest fullness being in the hand and proximal portions of the fingers and tapering toward the tips. There was a sinus over the dorsum of the first phalangeal joint of the index finger. In both amputated fingers, encircling the ends of the tendons projecting beyond the line of excision, necrotic tissue which diminished in amount distally was seen. In

the middle finger necrosis had extended to the tendons. Very little pus was present. The osseous surface of the proximal phalanx of the index finger was roughened.

"In the hand three sinuses were present on the palmar aspect surrounded by exuberant granulation tissue. Over the dorsum of the hand were several sinuses. No healing had occurred at the site where the fingers had previously been removed. Instead, cavities surrounded by excessive granulation tissue and exuding pus were seen. The necrotic ends of the flexor tendons to the fourth and fifth fingers projected from granulating cavities. The external disfigurement, swelling and profuse granulations about the sinuses and sites where the fingers were removed are shown by Fig. 2.

"On dissection, in the depths of the hand the deep tendons to the two remaining fingers were sloughing, partly necrotic and bathed in pus. All of this continued throughout, extending proximally to the level of the transverse carpal ligament. The distal ends of the first and second metacarpal bones were necrotic, but the process did not extend to the distal ends of the ulna and radius.

"On microscopical examination the epithelial layer of the skin, except in the ulcerating areas, appeared normal. However, even the most superficial layer of the corium contained an increased number of polymorphonuclear neutrophiles and plasma-cells, usu-

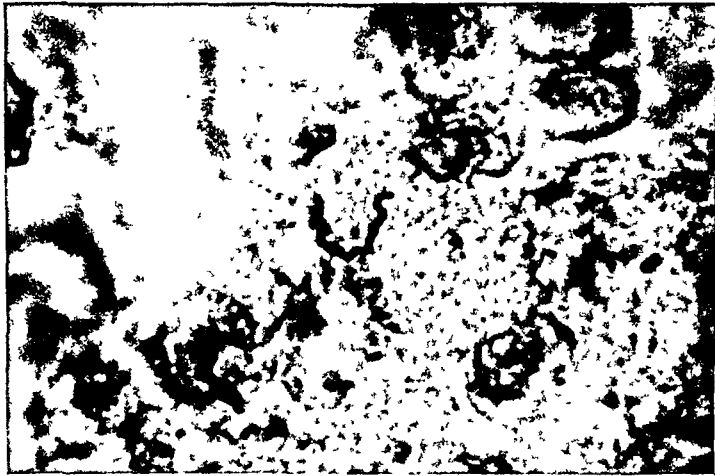


FIG. 3.—Case III. Photomicrograph of a section of tissue from right index finger under oil immersion objective, showing a typical spirochæte in the center of the field.

ally scattered about the blood-vessels and cutaneous glands. Deeper in the œdematous subcutaneous and areolar tissue the infiltrating cells increased in number and became associated with fibroblasts and a few eosinophiles. Frequent small hæmorrhages were seen. In the vicinity of sinuses or superficial ulcers, the surrounding granulations were heavily infiltrated with plasma-cells and polymorphonuclear neutrophiles, which continued through the subcutaneous tissue, fat, muscle and periosteum into the bone. In the bone the osteoblasts appeared larger than usual. Usually where the osteoblasts were missing, many giant cells were seen just beyond the outer lamellæ of bone. The superficial marrow spaces were infiltrated with cells, almost as abundant as those just outside the bone, but gradually diminishing toward the depths, where an increased number of fibroblasts suggested a barrier against the invasion. However, this barrier did not prevent a moderate number of infiltrating cells from penetrating the depths of the marrow spaces, now showing the typical loose areolar structure. In the hand where the infection had progressed over a wide area, extensive necrosis of the bones, overlying muscle and fibrous tissue, devoid of infiltrating cells, was seen. The tendinous sloughs were completely acellular and gangrenous.

"Numerous microorganisms were seen. Usually in the deeper areas, beneath the

SPIROCHÆTAL (TREPONEMA VINCENTI) INFECTIONS OF HAND

masses of bacilli and cocci, typical irregularly curved spirochætes were present, as illustrated by Fig. 3."

CASE IV.—A Negro man, aged thirty-two years (Pennsylvania Hospital, Unit History No. 20,902), applied to the Pennsylvania Hospital April 15, 1931, for treatment of a human bite of his right thumb received on that day. The wound was treated with iodine, a dry dressing applied and the patient instructed to attend the dispensary for further care. Apparently infection was present two days later when he first visited the Out-patient Department, as wet dressings were ordered. April 22, he was admitted to the house. At this time examination disclosed a swollen and œdematous thumb. There was a tooth wound on the dorsum of the proximal phalanx which was discharging foul-smelling pus. A moderate axillary lymphadenitis was present. Proper drainage was instituted in the Receiving Ward of the hospital and hot salt-solution dressings applied. A microscopical examination of a smear of the pus showed many spirochætes and fusiform bacilli. April 29, he was given neoarsphenamine 0.3 grams intravenously. By May 11 the wounds were healed, but some tenderness and slight œdema persisted.

CASE V.—A Negro man, aged thirty-seven years (Bryn Mawr Hospital, Unit History No. 01,054), was admitted to the Bryn Mawr Hospital June 4, 1931, with a history of having lacerated his right thumb on a piece of tin in a fall while walking through a woods. This occurred May 30. The same evening the thumb became swollen and tender. He attended the out-patient clinic of the hospital, but as the infection was not responding to treatment he was admitted to the house. Examination showed a markedly swollen and tender thumb with a laceration on the flexor surface at the base of the distal phalanx which was draining thin yellowish pus. The thumb was incised and continuous hot salt-solution dressings used. Later dressings wet with potassium-permanganate solution were tried. The wound developed a foul odor, the flexor tendons sloughed and the terminal phalanx became dislocated dorsally. Microscopical examination of smears of the pus from the wound showed a great number of typical fusiform bacilli, but no spirochætes. Dr. William P. Belk, pathologist to the hospital, made a diagnosis of Vincent's infection. The patient had a low grade fever during his stay in the hospital. June 17, eighteen days after receiving the injury, amputation of the thumb was advised. The patient, however, signed a release and left the hospital.

While spirochætes were not actually found on microscopical examination in this case we have included it as a spirochætal infection because of the clinical characteristics and the finding of large numbers of typical fusiform bacilli.

Six cases of spirochætal (*treponema vincenti*) infection of the hand have been observed by us. Of these, one died from the disease, one required amputation of the hand, one amputation of a phalanx and all but one case had bone or joint involvement of some degree. One hesitates to place confidence in inferences based upon the study of a few cases. It is our belief, however, that this infection once established permeates the tissues beneath the surface, that it is prone to attack bones and joints and that it does not respond favorably to the methods commonly employed in the treatment of infected wounds. The involvement of bones and joints is not necessarily due to deep penetration of the object which produces the wound. Thus, in Case III, the infection which resulted in destruction of all the metacarpophalangeal joints except that of the thumb was introduced by pricking a blister on the dorsum of the hand with a contaminated pocket-knife. In Hultgen's case, that of a child who had the habit of biting her fingers, bone destruction occurred within a week of the onset of the infection. Here it is fair to assume that the infection was introduced through a slight break in surface continuity.

Clinically, wounds infected with the spirochæte and fusiform bacillus are characterized by gangrene of tissues and a foul odor. The time elapsing between the reception of the injury and the development of these characteristics is brief. Swelling, œdema and tenderness of the part develop as the infection progresses and later sinus formation is not uncommon. In only one of the cases observed by us, that which was reported in 1929, was the systemic reaction alarming. Pain, although present in all of our cases, was not a conspicuous symptom nor did we note severe febrile reaction.

The treatment of this condition has not been satisfactory in our experience. This in part has been due to our failure to recognize early the seriousness of the infection and to treat it accordingly. We have erred perhaps on the side of conservatism in not opening widely the infected areas at the start. A course of intravenous injections of neoarsphenamine probably should be given in cases of established infection.

Foul-smelling gangrenous affections of the fingers and hand should be studied carefully for spirochætes and fusiform bacilli. These organisms are anaërobic and cannot be cultivated by ordinary methods, but can be detected by the examination of thin smears of pus obtained from the depths of the wound.

Wounds made by human teeth should be regarded as potentially infected and so treated. Bates¹³ advocates cauterization with the electric cautery. He has treated over one hundred cases of human bites, some as late as the third or fourth day, by electro-cauterization and extension of the infection thereafter has occurred in only one case. He attributes his very satisfactory results to the immediate destruction of the primary focus of infection.

BIBLIOGRAPHY

- ¹ Tunncliffe, Ruth: Life Cycle of *Bacillus Fusiformis*. Jour. Infect. Dis., vol. xxxiii, pp. 147-154, August, 1923.
- ² Topley, W. W. C., and Wilson, G. S.: The Principles of Bacteriology and Immunity. vol. xi, p. 1179, William Wood and Company, 1929.
- ³ Harrell, Voss: The Present Status of Plaut-Vincent's Infection. Arch. of Otolaryngol., vol. xiv, No. 1, pp. 1-8, July, 1931.
- ⁴ Hultgen, J. F.: Partial Gangrene of the Left Index Finger Caused by a Symbiosis of the Fusiform Bacillus and the Spirochæta Denticola. Jour. Am. Med. Assn., vol. lv, p. 857, 1910.
- ⁵ Peters, W. H.: Hand Infection Apparently Due to *Bacillus Fusiformis*. Jour. Infect. Dis., vol. viii, pp. 455-462, 1911.
- ⁶ Hennessy, P. H., Madras, C. M., and Fletcher, William: Infection with the Organisms of Vincent's Angina Following Man Bite. Lancet, vol. ii, pp. 127-128, July 17, 1920.
- ⁷ Hennessy, P. H.: Human Bites. Indian Med. Gaz., vol. lv, p. 250, July, 1920.
- ⁸ Pilot, I., and Meyer, K. A.: Fusiform Bacilli and Spirochætes; Occurrence in Gangrenous Lesions of Fingers: Report of Case. Arch. Dermat. and Syph., vol. xii, pp. 837-839, 1925.
- ⁹ Fuller, C. Rex, and Cottrell, J. C.: Infection with Organisms of Vincent's Angina Following Human Bite. Jour. Am. Med. Assn., vol. xcii, p. 2017, 1929.
- ¹⁰ Bower, G. C., and Lang, H. B.: Case Report of Finger Infection Due to Fusi-spirochætal Organisms. New York State Jour. Med., vol. xxx, p. 975, August 15, 1930.

SPIROCHÆTAL (TREPONEMA VINCENTI) INFECTIONS OF HAND

- ¹¹ Mason, M. L., and Koch, S. L.: Human Bite Infections of Hand with Study of Routes of Extension of Infection from Dorsum of Hand. *Surg., Gynec., and Obst.*, vol. li, pp. 591-625, November, 1930.
- ¹² Flick, J. B.: Gangrenous Infection of the Hand and Forearm Following Human Bite. *ANNALS OF SURGERY*, vol. xc, p. 450, 1929.
- ¹³ Bates, W.: Electro-cauterization in Treatment of Human Bites. *ANNALS OF SURGERY*, vol. xciii, pp. 641-644, March, 1931.

DR. FRANK L. MELENEY (New York) remarked that he could not recall having seen a case of foul gangrene following a human bite although he had always been impressed with the seriousness of other infections resulting from such an injury. The hospital's files for fifteen years failed to reveal a similar case. This type of infection is almost certainly a disease due to a mixture or symbiosis of organisms. There has been a good deal of discussion among the bacteriologists with regard to the fusiform bacillus and the spirochæte found in Vincent's infection—whether it is a symbiosis of two different organisms or whether the spirochæte is a phase in the life cycle of the bacillus. Ruth Tunnicliff claims that she was able to see spirochætes develop in the long threads which form in old cultures of the fusiform organism. Most of the other investigators say that although curved forms occur in the old cultures of the fusiform organism, they are not true spirochætes and that in Vincent's infection there is a real symbiosis between a fusiform bacillus and a real spirochæte. Knorr, who has studied Vincent's infection in many forms, believes it to be a true symbiosis and has found that in his cultures they are always associated with streptococci. He demonstrated in his cultures that first the streptococcus predominated, then the fusiform bacillus, and then the spirochæte, as if one organism prepared the ground for the next. He believes that the infection in man is usually initiated by the streptococcus. Doctor Flick said that other organisms beside the spirochæte were always present in his cases. In practically all cases streptococci are present along with the fusiform bacilli and spirochætes. Ruth Tunnicliff saw only one case of Vincent's infection in which streptococci were not present. Varney has made careful studies and believes the fusiform bacilli to be distinct from the spirochætes. Recently, Smith, at Raybrook Sanatorium, in a study of lung infections has done some interesting experimentation on the symbiosis of the organisms found in Vincent's infection. Invariably he was able to isolate at least four different species, streptococci, of the non-hæmolytic and anaërobic types, fusiform bacilli, spirilla and spirochætes. By inoculating with pure cultures, no lesion was produced. After inoculation of various combinations of these organisms into the trachea of rabbits, all of the typical lesions which are found in chronic infections of the lung were produced—bronchitis, pneumonia, bronchiectasis, abscess and gangrene. There had to be a combination of organisms to produce any of these, and the greater the number of different species used, the severer the lesion was. Gangrene was produced only when all four species were used.

Surgeons are just beginning to have an understanding of symbiotic

infections, and are just beginning to observe that certain chronic infections are due to the presence of two different species of organisms. For example, the chronic progressive gangrene of the abdominal wall, such as has been seen following drainage of certain peritoneal abscesses, is almost certainly one of these infections. Amœbic infections are probably symbiotic. Amœbæ will not grow artificially in pure culture. Why gangrene or destruction of tissue develops when certain organisms are growing together is still an unsolved problem. It needs further study. In the laboratory certain chance observations of mixed cultures indicate that with any particular symbiotic or synergistic phenomenon—for example, the formation of gas—one organism seems to initiate the process while the other continues or finishes it. This is probably true in a destructive lesion, in which one or more species of organisms are present. These cases suggest more frequent consideration of the possibility of symbiotic or synergistic infections in all regions of the body where numbers of different species of organisms are likely to be present, such as the gastro-intestinal tract, from the mouth to the anus. For example, the very severe infections following lesions in the œsophagus, such as a diverticulum which has ruptured followed by mediastinal abscess, are well known. Peritonitis following lesions of the gut is almost certainly in this group. Lesions of the respiratory tract, from the common cold to lung abscess and gangrene, must be studied from this standpoint. In all of these instances one must consider the effect of the organisms working together in the production of the disease. Until we learn more from a bacteriological standpoint about these foul infections following human bites, we shall have to content ourselves with radical surgery, both for the prophylactic and active treatment.

DR. WILLIAM BATES (Philadelphia) said that in these virulent infections of the hand, sometimes the bacterial flora in the wound corresponded with culture from the mouth, sometimes it did not. Early in his studies, he tried to prevent spread by multiple large incisions and all types of antiseptics without influencing it to any marked degree. He found that if the periosteum was injured by the tooth that osteomyelitis and resulting amputation occurred rather promptly.

The failure to control these wounds by ordinary surgical methods led to the use of the cautery. He now anæsthetizes the patient, excises the whole depth of the bite with the cautery and leaves a sterile, painless, open ulcer to heal by granulation. He had had exceptional success since starting this type of treatment. There had been necessary only two amputations; one of these was complicated by a compound fracture at the site of the infection and the other had existed forty-eight hours before applying for treatment.

In a series of cases previously reported by other writers, it was found that hospitalization in this type of wound averaged fifty-four days, whereas in a series of 130 cases now treated early by electrical cautery, they had hospitalized only the two cases referred to as exceptions.

SPIROCHÆTAL (TREPONEMA VINCENTI) INFECTIONS OF HAND

DR. HUBLEY R. OWEN (Philadelphia) remarked that there is no type of wound which is as dreaded by police surgeons as the lacerated wound of the hand caused by a tooth. In looking up the Philadelphia police records for the past three years, he has had twenty-eight cases of this character. He routinely has examinations made for spirochætes, and has found spirochætes (non-luetic) in nine of these cases. He had previously reported three luetic infections occurring as a result of these knuckle cuts. (Fig. 4.)

Various methods of treatment, including cauterizing with the actual cau-

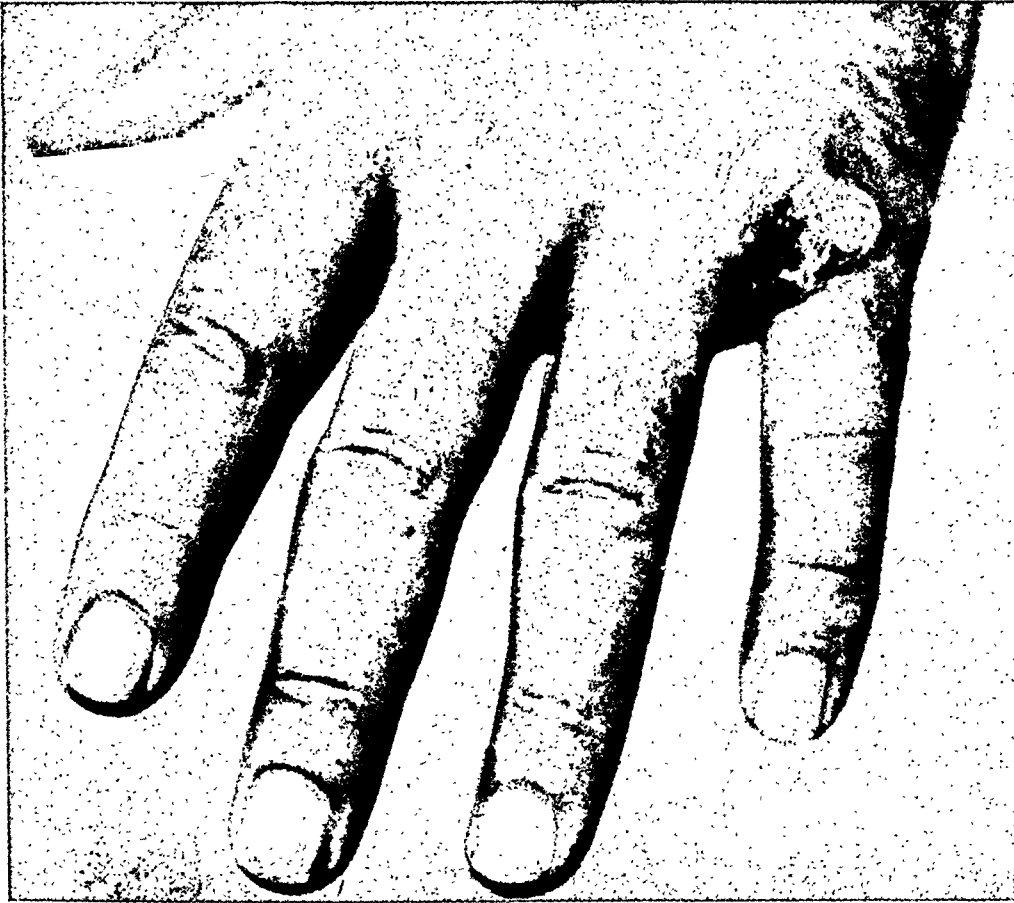


FIG. 4.—Chancre of hand following a tooth wound.

tery, have been employed. No method has given uniformly good results. He now treats these wounds as one treats any primarily infected wound. No improvement in results has been seen following the use of the actual cautery. Free and open drainage with rest has given the best result.

Several years ago, at a meeting of the police and fire surgeons, this type of wound was discussed. Dr. J. J. Moorhead, of New York, stated that one reason this type of infection is so frequently followed by destruction of the metacarpal-phalangeal joint with erosion of the cartilage and subsequent ankylosis is because "an injured cartilage never forgets a bruise." The cartilage, having poor blood supply, has neither the resistive power against infection nor the power of reconstruction.

All medical students and internes should be taught the danger of this

type of wound and should be especially instructed that such lacerated wounds caused by teeth should never be sutured.

THE TREATMENT OF COMPOUND FRACTURES

DR. CALVIN M. SMYTH, JR. (Philadelphia), said that in spite of a voluminous literature on the subject of compound fractures and their management, there is practically no uniformity of opinion as to the best method of treatment and no standardized procedure for handling them in most hospitals. This is in spite of the fact that Lister made the treatment of compound fracture the basis of his original contribution to antiseptic surgery and that from Lister's time to the present the subject has been ever prominently before the surgical profession. In pre-Listerian surgery, the man so unfortunate as to sustain a compound fracture stood a very good chance of losing life or limb, through sepsis or amputation, and the former not infrequently followed the latter. The introduction of the Thomas splint brought about a striking reduction in the mortality and morbidity of compound fracture of the femur and the Carrel-Dakin technic materially reduced the incidence of infection with its immediate and remote complications. Nevertheless, it is still apparent that certain fundamental rules that should be invariably observed in this type of surgery are constantly violated for one reason or another. One fact that cannot be emphasized too strongly is that the ultimate result in a compound fracture is most often determined within the first hour of the existence of the condition and depends on what is done, or, more often, left undone by the one who sees it at that time. The physician called first is not infrequently tempted to do too much to these cases and hospital house officers to do too little. All compound fractures are operative emergencies and should be so considered. The surgery required is worthy of the best efforts of the senior members of a surgical staff and should not be delegated to inexperienced assistants. It is bad policy to allow these injuries to receive so-called first aid in accident and receiving wards and the interests of the patient are best served by postponing anything beyond temporary splinting and possibly flooding with iodine until formal surgery with adequate anæsthesia can be instituted. On this point probably all surgeons are in agreement. As to just what should be done at the formal operation there is perhaps a justifiable difference of opinion.

Experience with a fairly large traumatic service would seem to warrant the drawing of certain conclusions in this connection. First, all compound fractures should be thoroughly débrided and opened widely in order to provide adequate drainage and prevent subcutaneous pocketing. Second, the question of whether the fracture was compounded from without in or within out is one of purely academic interest and should not influence the type or extent of the operation. Third, in the desire to prevent infection, one must not lose sight of the fact that one is dealing not only with a contaminated wound but also with a fracture. No operation is complete unless the fracture

is reduced and adequate provision made for its retention. In the vast majority of cases this can be done without adding to the risk of the patient and it also reduces the time of hospitalization—an economic factor of much importance especially in these times of depression. Fourth, the ideal operation is one which will accomplish these desiderata and in addition will not require frequent, painful and meddlesome dressings, which, of necessity, disturb the fracture. In a small group of cases seen early and where the contamination has been slight, Sherman's plan of reduction, plating and immediate closure has undoubtedly given good results. It most certainly affords every advantage to the fracture itself and does not require dressing. (Its applicability, however, is strictly limited.) Débridement followed by the insertion of Dakin's tubes in cases badly lacerated and contaminated has also given gratifying results where strict adherence to the Carrel-Dakin technic is insisted upon. In this method the wound receives the maximum attention and the fracture the minimum. The dressings are time-consuming, must be made daily and the patient must be disturbed for irrigation every two hours.

A method of treatment popularly known as the Orr method is at present undergoing a trial in a number of clinics. This method consists essentially of extensive débridement, reduction and fixation of the fragments, packing wide open with vaseline gauze and complete encasement in plaster. The original dressing is not disturbed for four weeks. In the hands of those who have used it, it has given great satisfaction, but a number of surgeons of large experience have expressed unwillingness to try it on account of real or implied dangers, although these same surgeons do not hesitate to employ it in cases of both acute and chronic osteomyelitis. The objections advanced against this form of treatment are based largely upon the danger of encasing a presumably infected wound in plaster, and particularly the danger of anaërobic infection. Experience has demonstrated, however, that this fear is not warranted by the results obtained by those who advocate the method. The speaker has personal knowledge of only one case in which gas infection developed following the Orr operation and this was in a patient seen by Dr. Fenwick Beekman and reported in a personal communication. In this instance the condition manifested itself on the third day and progressed to a fatal termination. Anaërobic infection is certainly to be considered in any injury the result of a street or a machinery accident and due precautions must be taken against it. While the incidence of tetanus appears to be on the decrease, in the Philadelphia area at least, we are seeing more cases of gas gangrene than formerly. A number of writers have drawn attention to this in the recent literature of gas gangrene in civil practice. Recognizing this danger in all compound-fracture cases, whether treated by the Orr method or not, a prophylactic dose of the combined tetanus and gas serum should be given. Before the introduction of the combined serum he employed the two separately, first using the perfringens and later the polyvalent serum. In no case had he had anaërobic infection develop. The justification for giving

serum to these cases has been questioned by some surgeons on the ground that it was unnecessary, although those who question it do not hesitate to give antitetanic serum in all street injuries. It is admitted that in many instances this is an unnecessary precaution but it would seem quite as logical to give the combined serum as antitetanic serum alone.

Others advance the argument that wounds such as commonly accompany compound fractures should be dressed in a manner permitting frequent inspection and dressing, in order that proper measures may be applied to the infection which so frequently appears. The answer to this objection is that cases treated by the Orr method do not become infected and that wound infection and osteomyelitis were more often the result of meddlesome dressings than of original contamination. When the first dressing is made at the end of four weeks, the wound and dressings are found soaked through with what at first glance appears to be pus, but which when wiped away leaves a clean granulating surface which heals promptly by granulation or in which healing can be hastened by skin grafting. Plaster is reapplied as at first and no further dressing made until union has taken place. When the second casing is removed the wound is usually solidly healed. This course is in striking contrast to that in which the daily dressings, irrigations, *etc.*, have been employed, and a very important factor is that the fracture has had the advantages of early and complete reduction and uninterrupted fixation.

He was not pleading for the employment of the Orr method in every compound fracture, for in certain cases, namely, those with extensive skin and muscle lacerations, stripping injury or cases not seen until infection has set in, it is clearly not indicated. He did, however, wish to state that in his experience with a small but constantly increasing series it has given greater satisfaction than any method heretofore employed and has been absolutely free from any of the objections brought forward by those who oppose its use. It is essentially a method of dressing rather than an operation and it is, of course, a well-established fact that no method of dressing can be a substitute for the good surgery which should precede it.

DR. JOHN F. CONNORS (New York) remarked that he had tried the Orr treatment and was not encouraged by the results. He said it may be that the fault was his own. For the past year he had used another line of treatment which he thought had given better results. Of 564 fractures, sixty were compound. The routine followed is this: Every case that comes into the hospital now is splinted on the spot where found. It is brought immediately to X-ray and then to the operating room, where the operation is performed. The wound is covered with iodoform gauze, the rest of the extremity cleaned with soap and water and then benzine. The wound is then cleaned with benzine and ether and débrided. If possible it is closed primarily. If it seems not suitable for closure, it is allowed to stay open. The results by this method are as good or better than by other methods of treatment. Of these sixty cases of compound fracture, twelve died. Of the sixty cases, thirty-two

were of the tibia and fibula, and in these cases he had tried to make two series, giving sixteen cases to the man who advocates leaving the case open, and the other sixteen to the man who thinks primary closure is the best treatment. The results were very good except in four cases, and these were four with primary suture. He believed there is something in the Orr treatment but he has not been able to accomplish it. The simplest way is to put the bone in position when on the table, débride as thoroughly as possible, put the bones in position and apply traction.

The following are the figures on his mortality in compound fractures. In two cases of compound fracture of the radius and ulna, both developed gas infection. One was caused by a gunshot wound, sawed-off shot-gun. The other died from gas infection which developed three days after admission. One femur died twenty-one days after the accident, septicæmia having developed. There were three deaths in compound fractures of the tibia and fibula. One case died in three hours. Patient was run over by a subway train. Another case died in twelve hours. This patient has a severe evulsion with a severe comminution of two-thirds of both bones. The third case died following amputation of both legs; this patient had been pinned between a building and an automobile. In sixty cases of compound fractures seven had amputations. All patients who recovered left the hospital with union.

Doctor Connors uses no plaster bandage, but relies on traction and a supporting splint to maintain alignment.

DR. EDWARD T. CROSSAN (Philadelphia) said that on the Ashhurst service at the Episcopalian Hospital they are still having good results with incision, replacing of the fragments, immediate suture and immobilization—with the exception of compound fractures of the hand. In the latter type of fracture, he thinks Orr's method is the most efficient treatment; it prevents accumulation of the extravasated products that cause fibrosis, resulting in limitation of motion. Fracture of the tibia with compounding in mesial surface will always be suitable for excision and immediate closure or a sliding flap. It may be that the fact that we do not know gas-bacillus infection causes us to continue with our method of treatment. We have seen only two cases in the last twenty years.

DR. FRANK L. MELENEY (New York) said that within the past two or three years gas-gangrene sera have been made more potent than in former years. Following the suggestion of certain bacteriologists, the biological products firms have put out serum which is potent against all of the gas-gangrene organisms as well as tetanus. There seems to be definite indication for the extensive use of this serum and a prophylactic in all cases in which there is likelihood of animal or human fecal contamination, in badly lacerated wounds and in these cases of compound fracture under consideration.

DR. FENWICK BEEKMAN (New York) said that it is a mistake to say that the treatment of compound fractures should be standardized, that is,

all cases must be treated in the same manner. This is impossible because much depends upon the type of wound and the possibility of contamination. Many fractures are produced from within out by indirect violence, the skin being broken over the angle formed by the broken fragments. He did not think in many of these cases the fragments actually pierce the skin—the latter is simply broken over it. These cases can usually be handled by cleaning the skin and wound superficially and then placing the part in a molded plaster splint or plaster case, just as in a simple fracture. Then we have the severe wound in which the fracture is produced by direct violence, the soft parts have been lacerated before the bone has been broken. These are due to direct violence. Such an injury is quite a different proposition from the first type mentioned. It is the type in which one usually sees gas gangrene. The streets of Philadelphia must be cleaner than those of New York—from what Doctor Crossan says—as we see many cases of gas gangrene in Bellevue Hospital. In the speaker's service he has about six cases a year, if not more. He would be afraid to put such injuries, fractures with wounds produced from without in, up in plaster. The case about which he spoke to Doctor Smyth a year ago was an individual with a compound fracture of the thigh, treated in one of their hospitals and débrided by a man who had had much experience during the War. The wound was then partly closed, packed with vaseline gauze, and a case applied. He died in three days from a fulminating gas-gangrene infection. In the Children's Surgical Ward a child died in two days following avulsion of the skin of the leg. The Orr treatment in chronic osteomyelitis, whether due to acute hæmorrhagic osteomyelitis or to compound fracture, has been satisfactory but he does not feel that acute hæmorrhagic osteomyelitis or a fresh compound fracture should be treated by a method which hides the wound from inspection.

DR. CLAY RAY MURRAY (New York) remarked anent the question of closing compound wounds: It is more or less a matter of betting the patient's limb or convalescence against one's judgment. Regardless of what type operation is used, one of the lessons theoretically learned in the War concerning wounds is not put into practice. In a compound fracture the sutures were placed but not tied and the wound treated for four or five days, since a great many infections do not develop until after three or four days. The wound was treated in expectation of possible infection and if it did not develop, closure was practiced.

DR. WILLY MEYER (New York) recalled the early days of antisepsis, while being assistant at Professor Trendelenburg's Clinic at Bonn, Germany. Lister's principles had just been introduced. They had swung from the use of carbolic acid to bichloride. Compressed moss wrapped in sterile gauze was the favored dressing. The moss (*sphagnum*) was cut from large sheets according to size required and dipped once in bichloride solution 1:1000, when it became soft and swelled up like dough. Already at that time, 1882,

RECURRENT CALCULI IN THE URINARY TRACT

gauze was sterilized by live steam. We believed that in compound fractures it was important to investigate whether dirt had gotten into the depths of the wound. Therefore the fracture line was carefully inspected. Thorough drainage with tubes was instituted by means of wide incisions and then the wound thoroughly disinfected with bichloride, 1 to 1000, not the 1-5000 solution later on in use. Antiseptic dressing with that compound and evenly compressing moss was applied and then plaster bandages on top for proper immobilization. He remembered the joy of his chief when, after three or four weeks of not touching the wound, the first dressing was changed, while the patient had had a normal temperature. The limb was saved and the fracture went on to consolidation.

Since that time the increasing traffic in large cities, the motor cars, and later the World War, caused infinitely more cases and enlarged experience. But the general principles of treatment remained the same.

It seemed to the speaker that the proper primary inspection of the wound should not be forgotten and the patient should be brought immediately after the accident to a well-equipped hospital if that is possible. The proper care by the surgeon who attends to the wound first decides the fate of the patient.

Doctor Meyer recognized Doctor Connors' experience, and the figures he gave speak for themselves, only twelve deaths in sixty serious cases.

DOCTOR SMYTH in closing discussion said that in his own service at the Methodist Hospital and in the service of Doctor Pfeiffer at the Abington Hospital, forty-two cases of compound fracture had been treated by the Orr method. In no instance did gas gangrene develop nor was it necessary to remove a single plaster case. Doctor Smyth wished to emphasize his statement that the Orr operation was employed in suitable cases only and was not applicable to every compound fracture.

RECURRENT INFERIOR RADIOULNAR DISLOCATION

DR. ELDRIDGE L. ELIASON (Philadelphia) read a paper with the above title for which, with discussion, see page 27.

RECURRENT CALCULI IN THE URINARY TRACT

DR. ALEXANDER RANDALL (Philadelphia) presented a preliminary report of some work which he had been doing in an effort to avoid that unpleasant surgical sequence where, after the removal of a renal calculus, a recurrence rapidly follows. Of the variety of urinary concretions which we know to occur, in but one variety are we apparently approaching some understanding of its causative factors. This is the so-called earthy, or triple phosphatic stone. It has long been recognized that certain bacteria have a very limited range of chemical reaction in which they normally thrive. Today all bacteriological media are titrated to determine their pH reaction in order to successfully cultivate the types of organisms on which one is working. Change their cultural habitat in this one factor and bacteriostatic, or bac-

teriocidal, action is obtained. Surgeons have long trusted to urotropin as an urinary antiseptic and in order to insure the generation of formaldehyde, an acid medium is necessary. For this purpose, acidifying drugs are given by mouth in order to assure an acid urine. He had long felt that possibly the acidifying drugs are of greater antiseptic value than the urotropin in the dosage ordinarily administered.

There is recognized a group of organisms which have the power of breaking down urea in the urine with the formation of ammonia; the staphylococcus, certain strains of *Bacillus coli*, *Bacillus subtilis*, *Bacillus alkaligenes* and the *corynebacterium Thompsoni* are characteristic of this group. They create an alkaline urine by their ability to split urea and having created their ideal habitat, thrive therein. With the formation of an alkaline urine, there is a resultant precipitation of the alkaline inorganic salts of calcium, magnesium and ammonium, of which the characteristic phosphatic calculi are formed. Herein we have a clear insight of this probable etiological factor. Such phosphatic calculi have three characteristics: First, they are the most rapid growing form of stone seen; secondly, once their deposition starts, it is rarely superseded by the precipitation of other urinary salts; and thirdly, it is this variety of stone which the chronic stone producers and repeaters form.

In order to control this chemical change in the urine favorable for bacterial growth and phosphatic precipitation, he had carried out the following steps in his clinical material in an effort to obtain a prevention of the infection by changing the chemistry of the urine, and in so doing creating a habitat in which bacteria responsible for the same will not grow.

The first step was in the treatment of suprapubic fistulæ following cystotomy with subsequent drainage. The picture is familiar to all of the post-operative prostatic, whose wound breaks down, creating a surgical menace that is a marked detriment to normal healing and closure. These wounds appear to be essentially related to an alkalization of the urine, and at their worst present an ugly, sloughing gangrenous sore on whose walls and even on the abdominal skin there is likely to be deposited encrustations of phosphates. Some time ago we experienced the ease with which such encrustations could be removed—in fact, dissolved by the topical application of a 5 or 10 per cent. phosphoric-acid solution. The response in healing following such local treatment is marked; a healthy wound rapidly follows the separation of the ugly slough, with the complete disappearance of phosphatic encrustations. Even in the absence of such breaking down of the wound, an ammoniacal order appearing in the dressings to the initiated is a warning that trouble is in store. Since adopting this step, the handling of such cases by the topical application of this weak acid solution has become gratifyingly improved.

The second step in the clinical handling of these cases was in certain patients where, though the wound was saved from the threatened breaking down, nevertheless, the constant threat of such a possibility was evident in the persistent pool of alkaline urine draining from the bladder. No amount of acidifying drugs by mouth appears to be sufficient in these cases to change

the reaction of such an alkaline urine to an normal acidity, while topical applications to the fistula orifice fails of sufficient penetration. It was in such a case, some time ago, that he first attempted a direct irrigation of the bladder cavity with a solution of 1 per cent. phosphoric acid. The bladder not only tolerated this solution without discomfort, but a 2 or 3 per cent. solution could likewise be used without marked irritation being experienced by the patient. Such an irrigation caused a prompt return of normal bladder urinary acidity, and this once obtained, was easily held by the administration of the acidifying drugs by mouth.

This improvement in the handling of these cases has since become a routine step in all his suprapubic cystostomies, and he felt it to be a definite step in advance in controlling the possibility of post-operative infection with the type of organism which is recognized to have the above characteristics of both alkalinizing the urine and causing a precipitation of the earthy phosphates.

This finding naturally led to the third step in attempting to accomplish the same end in cases of recurrent calculi in the upper urinary tract. As stated before these stone repeaters practically always form phosphatic stones, and with this in view, he wished to report three cases in which he had irrigated the renal pelvis post-operatively with phosphoric-acid solution in an effort and hope that by so doing the prevention of infection with the organisms which have the above-described characteristics might be avoided, and if avoided, be a means towards the prevention of recurrent calculus disease in the upper urinary tract:

Doctor Randall then threw on the screen the X-ray studies of three cases.

The first patient had had a right nephrolithotomy and left ureterolithotomy performed by the late Dr. John B. Deaver. In July, 1930, a third operation, a right ureterolithotomy, was performed by Doctor Randall. Eight months later another large stone was found and subsequently removed from the right ureter. This patient received irrigations to the renal pelvis through his post-operative drainage tube and subsequently continued to have cystoscopical lavage of this right kidney and ureter with a 1 per cent. solution of phosphoric acid. February 8, 1932, the pH of his right pelvic urine was found to be 6.1.

The second case had a stone removed from his right kidney pelvis in November, 1931, subsequent to which the renal pelvis was irrigated on alternating days with either a 1 or 2 per cent. solution of phosphoric acid over a period of ten days, and his follow-up treatment continued as in the previous case. The pH of his right pelvic urine on February 8, 1932, was 5.2.

The third case had been operated on for an acute blockage of the right ureter, in September, 1928; and a second and third operation performed on the left renal pelvis, for stone, in July and August, 1929. A fourth operation was performed upon the right ureter for an acute blockage by stone in May, 1930. An observation by X-ray study, in November, 1930, showed minute calculi in both renal pelves; while ten months later, in September, 1931, each kidney pelvis was filled with typical coral calculi. This patient sustained a fall from horseback in November, 1931, and five days later developed an acute blockage of the right ureter, necessitating a fifth operation. X-ray studies following this fall when compared to the studies made two months prior demonstrated a fracture of the coral calculus in the right kidney pelvis, a fragment of which was

causing this acute blockage. At the last operation, a ureterolithotomy, pyelolithotomy and a nephrolithotomy were performed. For three weeks following this operation the right renal pelvis was irrigated on alternate days with a 1 per cent. phosphoric acid. The wound closed promptly on withdrawal of the drainage, and the plate taken on December 12, 1931, showed the absence of any calculi in the upper right urinary tract. It was further reported that continuation of pelvic lavage at ten- to fourteen-day intervals since the last operation has been maintained, and the pH of the right pelvic urine January 28, 1932, was 5.8, and the urine perfectly clear.

Experiments on dogs' kidneys have been performed by injecting through the ureter from a laparotomy incision a 1, 3 and 5 per cent. phosphoric acid. One kidney was removed immediately, and the second one removed at the end of forty-eight hours. He had not been able to demonstrate, on microscopical study of these experimental dogs' kidneys, any evidence of damage to the pelvic epithelial lining or the renal papillæ; nor is there any evidence in these sections of any caustic action from the use of the drug in the above strengths. He summarized his remarks as follows:

(1) Phosphoric acid 1 per cent. has an equivalent pH acidity to $\frac{10}{x}$ HCl, or approximately a pH of 1.5. Its bacteriocidal value is based thereon.

(2) Phosphoric acid 1 per cent. is practically isotonic and is approximately equivalent to a gastric acidity of 100.

(3) In experimental dogs, renal pelvis injected with 1, 3 and 5 per cent. phosphoric acid fail to show any destruction of pelvic lining epithelium, or damage to the renal papillæ.

(4) Three patients in whom renal pelvic lavage with 1 and 2 per cent. phosphoric acid solution has been used, either through post-operative drainage tube, or through ureteral catheter, have not experienced excessive renal pain or discomfort. The bladder is less tolerant than ureter or kidney pelvis, and the urethra the least tolerant of all.

(5) The renal pelvic urine in the above three recorded cases has recently been restudied and found to be pH 6.1; pH 5.2 and pH 5.8.

(6) This step in treating cases of recurrent renal calculi has a rationale in both co-related conditions in the lower urinary tract and in bacteriological findings.

CONCLUSIONS.—(1) By bladder lavage with phosphoric acid post-operatively, alkalization and phosphatic encrustations can be prevented.

(2) The treatment of staphylococcic cystitis, encrusting cystitis, leucoplakia and allied conditions by this means is indicated.

(3) The prevention of recurrent renal calculi of the phosphatic variety is being attempted with every indication of success.

(4) The possible dissolution of small phosphatic calculi, or fragments left at operation, may be expected by the recognized action of such strengths of phosphoric acid *in vitro*, and the tolerance to such topical applications *in vivo*.

DR. EDWIN BEER (New York) remarked that some years ago, the surgeon was satisfied with removal of the kidney stone or stones, and instructing the

patient following the operation to abstain from certain dietaries. Experience has shown that the situation is not as simple as this. The more kidney-stone cases one sees (in the last ten years we have had over 1,500 kidney- and ureter-stone cases), the more difficult it becomes to evaluate the factors that make for recurrence; and the more carefully cases are studied post-operatively, the greater the number of recurrences observed.

Before analyzing the problem, however, we must distinguish between real bona fide recurrences and false recurrences due to overlooked smaller or larger fragments, which have been allowed to remain in the kidney following what appeared to be a complete surgical evacuation. About thirty years ago, a similar discussion concerning gall-stone recurrences was carried on in medical literature, when the distinction between true and false recurrences was emphasized.

With the modern development of the surgery of kidney stones controlled by X-ray of the exposed kidney in the operating room, it has been possible to empty the kidney more completely than before this procedure was introduced. Fluoroscopical control of the exposed kidney has proven less satisfactory than photography on a small film with an intensifying screen. This objective control of the exposed kidney assures the surgeon as to whether all calculous material has been removed, and if there is any doubt, or sand has been encountered in the kidney during the removal of stones, the kidney can be drained either through the pelvis or through a nephrostomy to permit of subsequent discharge of these particles which may prove to be nuclei of subsequent new stones.

In addition to this control in the operating room, before discharge from the hospital, it is customary to take a series of flat pictures to confirm the operating-room findings. Unless all stones or fragments of stone are removed, unless one is sure one has emptied the kidney, a discussion of the incidence of true recurrences is of questionable value. If, however, all stones as controlled in this manner have been removed, and the kidney in the course of a few months, or years, develops a stone, then only can we consider that we have a true recurrence. In our experience, a solitary stone in the pelvis removed by pyelotomy is much less frequently followed by recurrence than those complicated stones usually associated with sand that are more or less dendritic in their structure, filling the pelvis and one or more calices, whether single or multiple. In this our experience is at variance with some other clinics, where more recurrences have been seen after simple single stone removal by pyelotomy than after the more complicated dendritic calculi. The factors underlying stone formation are fairly well evidenced in a number of organs of the body. Apparently, even without infection, stones may crystallize out of the fluid in which the chemical salts are present, and if stagnation is present, it favors this crystallization and deposition of salts. Apparently, in both the bile and in the urine, the salts, particularly cholesterolin and uric acid, are present in a supersaturated condition, and are held in solution by colloids. If one allows such acid urine which contains an excess of uric acid

to stand in a test tube, in the course of one to three days one can see frequently the colloidal nebecula separate from the urine and coincident with this the uric-acid crystals are thrown out and are deposited on the test tube. Similarly, in phosphaturia cases, the phosphates are thrown out as a lipoid colloid which collects on the top of the urine in the test tube. In prostatic obstruction with clear urine, there is frequently a tendency for urates to sediment out in the residual urine and stones apparently form as a result of this process; similarly, in the gall-bladder as a result of similar physical chemical changes, cholesterin stones develop.

If infection sets in, a totally different type of stone forms in both the urinary tract, kidney or bladder, or in the gall-bladder. In the above observations in the urinary bladder, stagnation of urine seems to be the clue to the formation of stones, and it is very likely that a similar stagnation in the kidney, both pelvis and calices, may contribute to the formation of primary uric acid, oxalate or phosphatic stones in this region. In the face of infection, stones of earthy phosphates are most likely to develop in the kidney, and it is our problem to control both the stagnation and infection in the kidney, if recurrent stones are to be avoided.

It has been my experience that in the lowest calyx, perhaps due to man's upright position, stones seem to form more frequently than in the other calices, either as primary calyceal stones or as extensions from a pelvic stone. If such a calyx becomes distorted and dilated, one can readily understand that stagnation in this calyx will persist and recurrence will probably develop even if little or no infection be present.

Dietary measures in controlling recurrence of kidney stones seems to be of very little value if deformity of the kidney and poor drainage are not controlled. Uric-acid calculi, which are present in between 6 per cent. and 10 per cent. of all cases, probably can be controlled by dietary measures. Phosphatic primary stones possibly can be controlled by making the urine highly acid. Oxalate stones cannot be prevented with any regularity by a low oxalate diet, though it is well worth while advising the patient to avoid foods rich in oxalates. Cystin stones also are hard to control, though some reports have suggested that alkalization may prevent reformation after removal of such stones. Recurrent stones in infected kidneys are much more difficult to control; even with pelvic lavage using antiseptics one cannot with any regularity control reformation.

At operation, however, one must establish free drainage from the kidney, and if it is possible, having found a dilated calyx, for instance in the lower pole, one should obliterate this pocket, either by using mattress sutures or by resection of the lower pole if the calyx is very large. Whether nephrostomy with irrigation is of value in preventing recurrence in these infected cases is highly doubtful. It does seem more advisable to rely upon natural diuresis and forced fluids to attempt to wash out the kidney cavity than to rely upon an occasional irrigation through the cortex or through the ureter catheter.

RECURRENT CALCULI IN THE URINARY TRACT

In some cases, however, in which much sand has been encountered, post-operative irrigation of the kidney through the nephrostomy tube with weak antiseptic, especially with hydrochloric or acetic-acid solution may dissolve some of the earthy phosphates and thus delay recurrences.

From these remarks it is evident that the problem is by no means simple and some writers have made the outlook a little more problematic by claiming that a vitamin deficiency underlies the whole process of stone formation. Whether this vitamin deficiency manifests itself in the above-mentioned colloidal instability or not has not been demonstrated, but it would not be surprising if such a colloidal instability resulted from either physico-chemical or dietetic disturbance.

In connection with Doctor Randall's experiments with phosphatic deposits following cystotomy operations, our experiences have been very much the same. These are difficult to control unless the urine is acid, and we have found that the best acidifier of the urine is ten grains of boric acid and sodium benzoate with ten grains of urotropin, to which ammonium chloride can be added as required. In addition in some of the more obstinate cases, hydrochloric acid and acetic acid up to 1-1000 or Gouley's solution or normalactol have been used with considerable success. In passing, I would call attention to the publication in the *Presse Medicale* by Meyer, in 1925, in which he calls attention to the fact that the secondary stones in the bladder can be dissolved by irrigations with the above types of acid solutions.

In the upper urinary tract, we have tried to dissolve out such stones by using a Murphy drip, double flow ureter catheter, and instilling gallons of the acid solution. No stones of any size have been dissolved in this way, though these various solutions in test tubes within one to two days usually dissolved even fair-sized calculi of the group under discussion. Small calculi and sand particles undoubtedly can be dissolved in the upper urinary tract by these methods, and, in fact, von Haberer about two years ago claimed that he regularly used normalactol, which is a lactic-acid solution with a buffer in all complicated stone cases to dissolve out residual fragments.

His experience is not quite as encouraging as Haberer's publication might suggest. On the whole, this is a new field, and he felt that with more intensive work along the lines suggested by Doctor Randall and in his remarks, eventually they will be able to do something very definite for these patients, not only in relieving stagnation and infection, but in changing the renal condition by various irrigation methods, which will dispose of stones before they get to be large recurrences.

DR. LEON HERMAN (Philadelphia) said that Doctor Randall's presentation is in the nature of a preliminary report, and, as he understands it, he does not mean that his analysis is the final word on the therapeutic value of phosphoric acid in the treatment of phosphatic urolithiasis. With this reservation, it would seem that this method of treatment, especially its prophylactic use after operation, has great advantages over prior methods. The speaker

questioned the justification for the routine use in phosphatic calculi in the kidneys. The modus of its action seems not to have been discovered, but it is well known that phosphatic stones occur only in the presence of infection, chiefly of the coccal types, and it might well be that local changes occur as the result of the action of phosphoric acid, which render the medium unsuited to bacterial life. Hexylresorcinol is extremely useful in the post-operative period, especially in the surgery of the lower urinary tract, its benefits being derived from the control of coccal infections. It will be interesting to observe the effects of phosphoric-acid irrigations of the kidney in those cases in which a nephrostomy tube is employed. Certainly the use of phosphoric acid as suggested by Doctor Randall is a decided forward step in the therapeutics of an extremely annoying condition.

REDUNDANT GASTRIC POLYP—GASTRIC MUCOSA PROLAPSE

DR. DAMON B. PFEIFFER reported the case of a woman, aged sixty-five years, who was admitted to the Lankenau Hospital, November 3, 1931, complaining of a lump in the right upper quadrant of her abdomen.

She was well developed, not emaciated; blood-pressure 180/26; the heart and lungs negative to examination; a lipoma, size of a lemon, in left breast; hæmoglobin, 65 per cent.; erythrocytes, 3,350,000; leucocytes, 6,800; Wassermann and Kahn, negative; icterus index, 5, Van den Bergh indirect, faintly positive direct negative; coagulation time 6.5 minutes; bleeding time, 8 minutes.

A rounded mass, the size of a large coconut, could be felt in the right upper quadrant of the abdomen, coming down from under the costal margin. It was smooth, symmetrical and was continuous below with the palpable edge of the liver, with which it moved on respiration. Gastro-intestinal X-ray showed the stomach displaced downwards and to the left; pyloroduodenal canal deformed and a defect in the shadow in pyloric region attributed to pressure. The cholecystogram showed a defective shadow which diminished, however, with fat meal. Barium enema showed only irritability of colon.

Under a diagnosis of hepatic tumor, cyst or abscess, she was operated upon November 11, 1931, under spinocaine anaesthesia. The mass proved to be a large, yellowish-red tumor of the liver, at first glance solitary, but on closer examination smaller nodules were found above the mass but in immediate relation to it. No other nodules were present in the left lobe or in the remainder of the right lobe. It was resilient and numerous blood-vessels coursed over its surface. It was thought to be an inoperable hæmangioma. A nodule about 1.5 inches in diameter was then observed in the gastrocolic omentum. There was no glandular enlargement in the neighborhood. On palpating the body of the stomach a movable mass was felt within the stomach, evidently a polyp. The nodule in the gastrocolic omentum was easily removed. By gastrotomy a polyp two inches long, swinging from a small soft pedicle, was seen. The stomach wall was apparently normal but the body of the polyp was friable. The polyp was excised at the base and the operation concluded with the intention of submitting the tumor of the liver to radiation. However, the patient died on the third day with symptoms of basal bronchopneumonia. No autopsy was permitted but a specimen of the tumor of the liver was removed which was pronounced metastatic carcinoma. The body of the gastric polyp was carcinomatous. The nodule in the gastrocolic omentum resembled the carcinomatous polyp in structure. The case is remarkable pathologically in that the malignant changes in the polyp did not involve the base or adjacent stomach while only two metastases were demonstrable, one in the gastrocolic omentum, evidently lymphatic-borne, while the liver metastasis must have been hæmatogenous.

REDUNDANT GASTRIC POLYP—GASTRIC MUCOSA PROLAPSE

He presented this case because of the increased interest in polypoid growths in general and gastric polyps in particular. If one excludes fungating or simple protuberant benign or malignant tumors, it would appear that true polyps of the stomach are rare. In the Obuchon Krankenhaus there were only four cases in 7,500 autopsies. Tilger found fourteen cases in 3,500 autopsies. They occur as (1) single or several discrete pedunculated tumors, or (2) as more or less widespread areas thickly beset with polypi (generalized polyposis or polypoidosis), or (3) as coalescent papillomatous tumors surmounting hypertrophied rugæ (polyadenoma en nappe of Menetrier). The last variety is exceedingly rare. Polypoidosis is a somewhat more com-

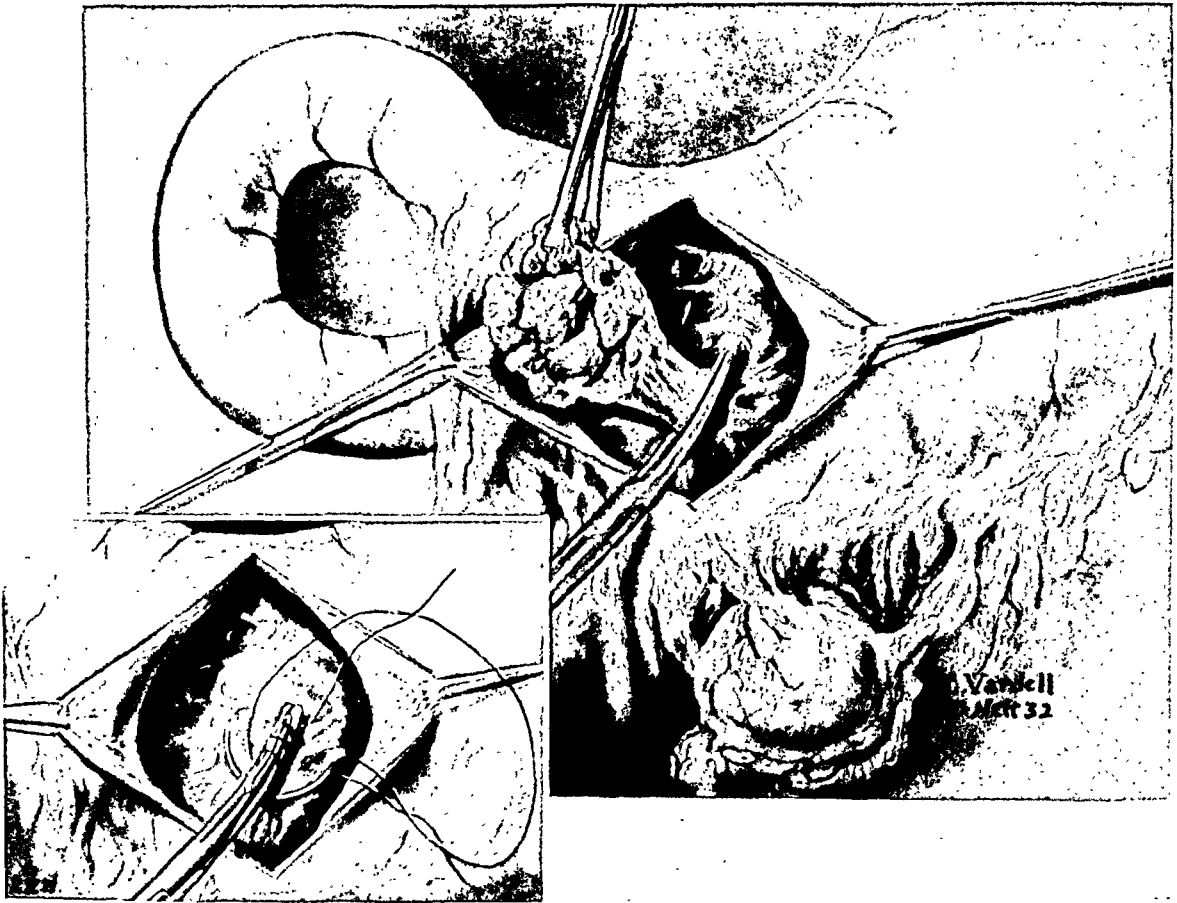


FIG. 5.—Gastric polyp and omental metastasis, overhanging mass in liver not shown.

mon condition and exhibits a strong familial tendency. Solitary polyps are more often found and may be adenomatous or simply polypoid fibroma, myoma, cyst or angioma. The chief dangers are hæmorrhage and malignant change. Bleeding is common and may be massive or small repeated losses bringing on profound anæmia. All patients with unexplained anæmias should be X-rayed with this possibility in mind.

Adenomatous polyps are prone to become carcinomatous. The symptomatology is indefinite. Tumors which prolapse through the pylorus usually cause some form of distress simulating ulcer or gall-bladder disease. Polyps of the body or fundus of the stomach are often silent. Gastric symptoms when accompanied by persistent loss of blood through the bowel may arouse

suspicion and indicate X-ray examination, upon which a clinical diagnosis of the condition depends. The speaker had a strong impression that owing to the difficulties of recognizing such growths, they are more common than at present suspected.

In 1925, Eliason, Pendergrass and Wright collected from the literature and their own experience a considerable number of pedunculated growths of the stomach in connection with an article on the Röntgen-ray diagnosis of these peculiar tumors. In this paper they presented two cases, which they believe to have been the first reported, of prolapsing mucous membrane of the stomach extending through the pylorus into the duodenum. These cases closely simulated in röntgenological signs the more frequent condition of pedunculated pyloric polyp extruded into the duodenum. In one of these cases several polyps were present on the prolapsing mucous membrane. In the other case no polyp was present. This case also had disease of the gall-bladder and a few stones as in the case here reported. It is difficult, therefore, to construct a clinical picture because of the paucity of cases and the chance that it is impossible to separate symptoms due to prolapse of the mucosa from possible gall-bladder symptoms. In any event the diagnosis is one to be made only by careful X-ray examination and equally careful surgical exploration. In a later paper in the Journal of the American Medical Association, February 1, 1930, Pendergrass analyzed the X-ray appearance of this lesion as follows:

Prolapsing Mucosa.—All of the phenomena noted in pedunculated tumors are observed in this condition, and, in addition, there is a defect in the pyloric region of the stomach which varies in direct proportion to the obliteration of the gastric canal. (1) If there is a large collar of prolapsing mucosa, there will be a wide pyloric space or filling defect. (2) If only a small collar is prolapsing, there will be a less dense opaque shadow in the pyloric region as compared to the density of the body of the stomach. (3) If the amount of prolapsing mucosa is less than 1 and more than 2, the pyloric defect will consist of longitudinal striations similar to those seen in hypertrophied rugæ of the stomach or when the stomach is only slightly filled and there is some pressure on the spine.

The condition is comparable to what the urologists describe as "floating trigone" of the urinary bladder in which the mucous membrane slides downwards and may obstruct the internal urinary meatus: and to the not infrequent condition of prolapse of the mucous membrane of the anus often seen in infants with or without true prolapse of the rectum. What its frequency or significance may be it is impossible to state, but it is in order to record cases as they occur so that conclusions may be drawn.

In regard to treatment, it seemed to be simplest to plicate the redundant mucosa and secure its adhesion to the outer coats. This is the principle employed in linear cauterization for prolapse of the mucous membrane of the anus, and it is efficient. No gastroenterostomy was done in this case. The result anatomically and clinically after this short interval is perfect.

REDUNDANT GASTRIC POLYP—GASTRIC MUCOSA PROLAPSE

DOCTOR PFEIFFER detailed also the history of a man, aged forty-one years, who was admitted to the Lankenau Hospital December 14, 1931. Ten years previously he began having attacks which he attributed to gas, beginning usually about 2 to 4 P.M., and lasting until midnight. Soda, belching, or vomiting seemed to relieve, but a heavy dull pain in the lumbar region often persisted for two or three days. Pain was never severe and had no association with any kind of food. Attacks at first came on at intervals of about six months, but latterly were becoming more frequent. Aside from these disturbances, he was very healthy and well and a thorough diagnostic survey

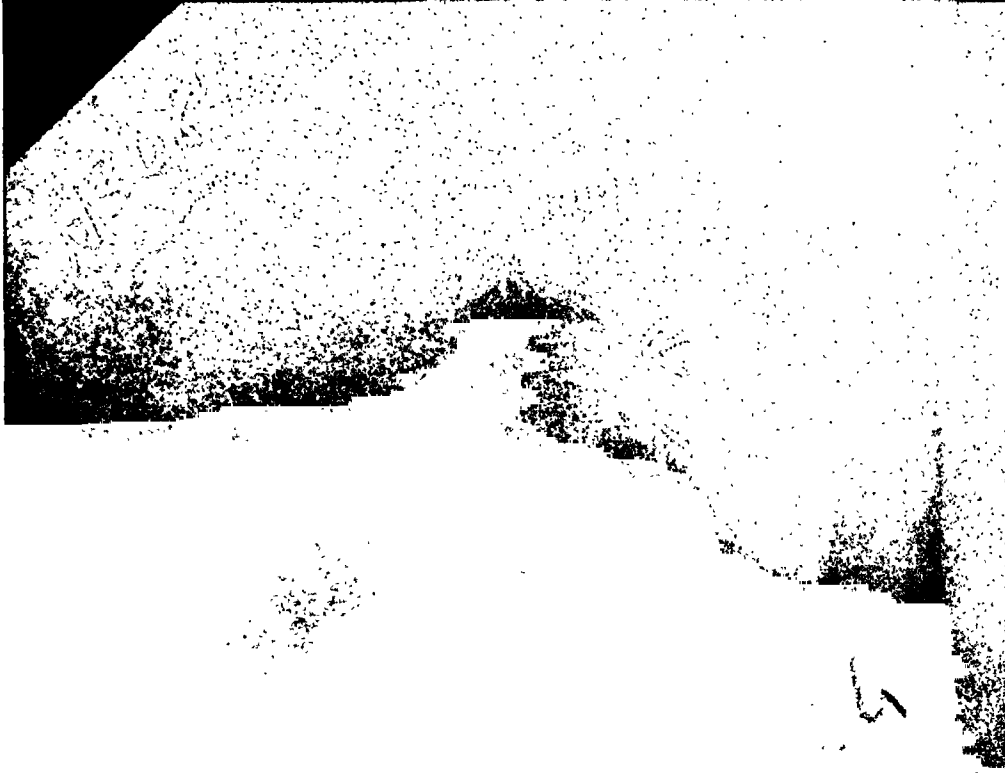


FIG. 6.—Defect in duodenal cap due to pseudo-polyp.

revealed no organic disease. X-ray films showed no gastric pathology but a constant clear defect was observed in the first portion of the duodenum exhibiting the characteristics of a polyp, and under this diagnosis he was admitted to the hospital.

At operation, December 16, 1931, the stomach, pylorus and duodenum appeared to be normal. The appendix was kinked at the base and was removed. The gall-bladder was very slightly thickened and was removed. No stones were palpated before removal but on opening the organ a few small sandlike concretions were found. The gastrocolic omentum was opened to permit more satisfactory palpation of the stomach. In this manner a curious elusive thickening could be felt about 1.5 inches proximal to the pylorus, more marked in relation to the lesser curvature. The anterior wall of the

stomach was incised and the duodenum and stomach aspirated free of contents. The interior of the duodenum and stomach were inspected and palpated. No polyp was present. Attention was then directed to the obvious redundancy of the gastric mucosa in the pyloric region. When grasped with Allis forceps a large fold could be picked



FIG 7—Normal duodenal cap after operation, evidences of gastric irritability due to plastic procedure

up and moved freely over the outer coats of the stomach wall. It could be made to glide downwards through the pyloric ring and it was concluded that this was an instance of sliding mucosa simulating polyp by extrusion into the duodenum. A considerable fold of the loose mucous membrane was picked up, oversewed with chromic catgut and attached to the underlying coats. Convalescence was uneventful. He has re-

REDUNDANT GASTRIC POLYP—GASTRIC MUCOSA PROLAPSE

maintained symptom-free and X-ray examination February 2, 1931, shows the stomach and duodenum to be normal with no trace of the previous defect.

DR. HENRY W. CAVE (New York) said that at the Roosevelt Hospital in New York, the experience with gastric polyp had been exceedingly limited. In 1902, Joseph A. Blake removed a single polyp which proved to be a benign adenoma. From 1910 to 1932, a twenty-one-year period, out of 993 operations upon the stomach, in not a single instance has there been recorded the presence of a polyp. However, recently, on the service of Dr. James I. Russell, a man of forty-five years of age presented an interesting problem.

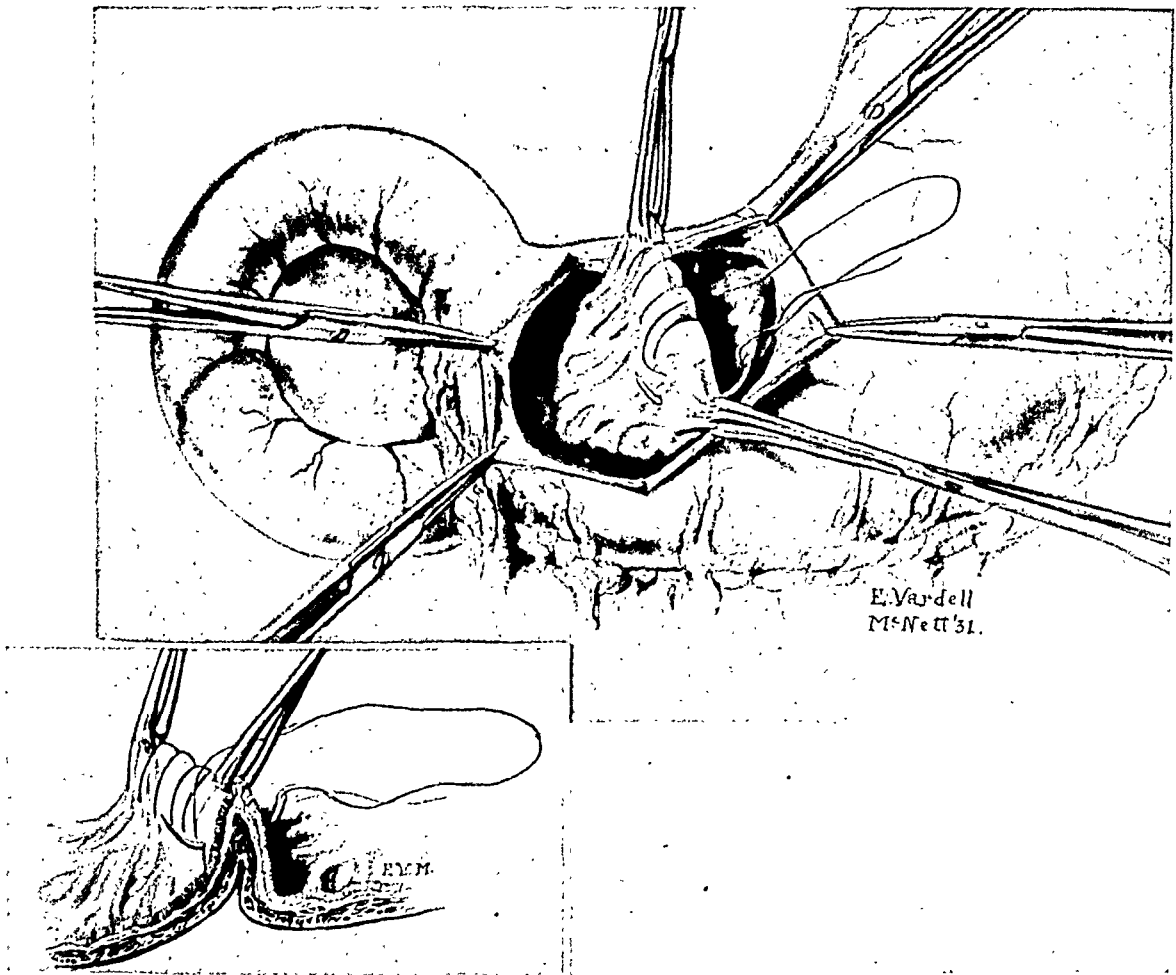


FIG. 8.—Semi-diagrammatic representation of plication of mucosa and submucosa.

This man had always been well until January 14, 1932, when he felt nauseated and vomited. Then for a period of two weeks he suffered much discomfort and cramp-like pain in the upper abdomen. He also had intermittent attacks of vomiting. X-rays showed a defect in the duodenal bulb. A diagnosis of gastric polyp was made. These intermittent attacks were thought to be due to pyloric blocking from a polyp. Twenty-four hours after admission increasing abdominal distension was noted. Flat X-ray plate of the abdomen showed a greatly distended loop of terminal ileum. The pre-operative diagnosis was new growth on ileocecal valve and possibly a gastric polyp. Immediate ileocolostomy was performed. Stomach was merely palpated, nothing abnormal

felt. Unfortunately, the man developed pneumonia and died February 9, 1932.

Considerable difference of opinion exists as to the instance of this condition. Gastric polypi and polyposis of the stomach should be clearly differentiated as they present two distinct clinical entities. Ebstein records fourteen cases of gastric polyp in 600 autopsies. Tilgen reports fourteen cases in 3,500 autopsies. Mulengracht found eleven cases in 11,475 post-mortem examinations. Stewart, of Leeds, in 11,000 autopsies found gastric polypi in forty-seven, and reported that thirteen out of 263 cases of cancer of the stomach, or 4.9 per cent., originated in polypi. Eliason and Wright, in 1925, collected 610 cases of primarily benign tumors of the stomach; fifty of these were from the University and Philadelphia General Hospitals. In 1930, these authors with Miller reported six additional cases of gastric polyp. The instance of malignant degeneration according to various authors ranges from 3.5 per cent. to 35 per cent. The etiology is unknown. It is believed frequently to be the result of chronic gastric catarrh and some think it is associated with the atrophic form of gastritis. Rokitsansky, with his experience of over 30,000 autopsies, believed they were the result of inflammatory irritation, or, in some cases, congenital. Many give no symptoms; many come giving symptoms of anæmia as the most prominent feature of their illness. The polyp situated near the pylorus with a long pedicle may prolapse through the ring and cause pain, nausea and vomiting of a very severe grade. The most common symptoms are anorexia, pain, nausea and vomiting (usually intermittent), loss of weight and anæmia. There may be present symptoms of pyloric obstruction, intussusception, hæmorrhage and malignancy. In size they range from the size of a lentil to that of a foetal head. In number they vary anywhere from 1 to 300. Gastric polypi may arise from either the outer surface of the stomach wall or the interior of the stomach wall. Those in the interior are usually situated in the pyloric segment, but may cover a considerable area or sometimes nearly the entire interior of the stomach. Sherron records eighteen cases, most of them mesoblastic tumors which projected from the greater and lesser curvatures of the stomach into the peritoneal cavity.

While undoubtedly the most valuable means of diagnosis, the X-ray is not infallible. In these cases röntgenological study shows no interference with gastric peristalsis. It does show, however, usually the delay in gastric motility with retention of part of the barium meal after six hours; invariably a vacuole either in the stomach or in the duodenum is seen. Goldsmith recently reported a case where the film showed regularly a limited defect which was rounded and about as large as a walnut in the pyloric segment. A diagnosis of benign tumor, probably a polyp, was made. On opening the stomach at operation a freely movable peachstone was found, the patient having swallowed this six months previously and it could not be passed through the pyloric ring. The X-rays are of little use in cases of solitary polyp, especially

if they do not cause mechanical symptoms or before carcinomatous degeneration takes place.

In regard to the treatment, gastrotomy is the only sure method of determining the presence of a polyp, and a gastroscope is often a valuable aid. Because of their close relationship to malignant disease, adenomata, fibromata and myxomata offer a serious prognosis and a subtotal gastrectomy should be done. Some authors insist that subtotal gastrectomy should be the operative choice in any type of gastric polyp.

DR. RICHARD LEWISOHN (New York) said that prolapse of the mucous membrane of the pylorus and secondary obstruction is rare. The first case was reported in 1911. In recent years interest has been revived by the studies of Eliason and Wight, who have undoubtedly collected a large number of cases, and in a number have made the correct diagnosis from the X-ray. The clinical pictures of prolapse of the mucous membrane and of gastric polyp are identical. Prolapse may go on to polyp formation and in some cases to secondary malignancy. The differential diagnosis is undoubtedly difficult, but it can be made.

REPAIR OF CLEFT PALATE

DR. GEORGE M. DORRANCE (Philadelphia) read a paper with the above title, for which see *ANNALS OF SURGERY*, May, 1932, vol. xcv, page 641.

DR. FRANK S. MATHEWS (New York) said that all operators must have felt the need of some operation which would displace the palate backward and allow the pharynx to be closed off in phonation and swallowing. In the Langenbeck operation, where tissues are approximated from side to side, the failure of the functional repair would seem to depend on lack of tissue in addition to the separation of tissues in the median line. Brophy insisted that cleft palate is simply a division of tissues and that there is no real deficiency. But this the speaker thought entirely erroneous. When in a Langenbeck operation a hole occurs at the suture line, it often heals completely by cicatrization, but this process still further draws the soft palate farther forward. Wandell, of Newcastle, has devised an operation with the intention of diminishing the gap between palate and posterior pharynx by bringing the posterior pharyngeal wall farther forward. The Dorrance operation seems a pretty severe one and requires multiple operations, and if infection with sloughing should occur, the disaster would be irremediable. The operation for cleft palate should be done only by those who have intimate knowledge of the anatomy of the parts, acquaintance with all the operative procedures, skill in operating and a kind of temperament which is chiefly characterized by self-control. Many otherwise good surgeons are not adapted to this kind of work.

DR. ROBERT H. IVY (Philadelphia) remarked that his personal experience with the Dorrance procedure has been limited to three cases, but he has had abundant opportunity to follow closely the work Doctor Dorrance has been doing from its inception and believes that this procedure is a very valuable

addition to the resources at our disposal in the treatment of certain forms of cleft palate.

There has been, and there still is, unfortunately, a tendency on the part of some surgeons to undertake cleft-palate operations with insufficient study of the problems involved in individual cases, and to look upon these cases as of minor importance when compared, for example, to major abdominal conditions. This is not as it should be, for failure of the first operation frequently ruins the case for a future good result, and there is surely not a more serious handicap to a person than to go throughout life with imperfect speech. Therefore, the surgeon who undertakes these cases should do so only after thoroughly familiarizing himself with the best technic available.

The von Langenbeck operation has been, and still is, regarded as the standard procedure in correction of cleft palate. In the past few years men especially interested in the cleft-palate problem have been taking stock, so to speak, and are becoming less and less satisfied with the von Langenbeck operation. A great drawback to this operation is that the lowering of the mucoperiosteal flaps in order to bring their edges together in the median line, and the detachment of the aponeurosis and nasal mucosa from the posterior edge of the hard palate necessarily create a dead space between the flaps and the bone above, leaving a broad, raw surface exposed to the nasal secretions. This creates a tendency toward nonunion, and even if complete union occurs, there is much scar tissue contracture which pulls forward the soft palate, creating insufficiency there, and preventing closure of the nasopharynx, so necessary for good speech. It has also been found that the von Langenbeck operation when performed early in life causes in some cases an arrested development of the upper jaw and irregularity of the teeth. For these reasons Doctor Ivy believes the von Langenbeck operation is going to be performed less and less often as time goes on. There is no time here to go into details of operative improvements that are gradually being substituted for the von Langenbeck operation, but he wished to refer especially to the recent book of Victor Veau, of Paris, in which the author describes a technic which he believes marks a great advance in this work. During the past four or five months the speaker has operated on fifteen cases by Veau's technic at various stages, and even with this short trial he is more than satisfied that the end-results are going to be vastly improved.

Doctor Dorrance's operation is especially adapted for primary cases of congenital insufficiency of the palate, with or without cleft, when neither the von Langenbeck nor any other technic will allow a shutting-off between the soft palate and the post-pharyngeal wall. It is also effective as a secondary procedure where the other operations, even though successful in closing the cleft in the median line, have not improved speech by reason of an insufficiency posteriorly.

DR. WARREN B. DAVIS said that he had used this technic at the Jefferson Hospital in six instances. Four of the six cases had short palates that had

CHRONIC CYSTIC MASTITIS

been repaired in earlier life. In two the palate was still cleft in the posterior half. The only radical difference between his method and that described by Doctor Dorrance is that in his cases the time elapsing between the two stages of the operations varied from eight to fourteen days. All of the patients were greatly improved in speech. In one case an opening in the palate just posterior to the incisor teeth persisted. A dental plate was used to cover this opening and the speaking voice is good.

CHRONIC CYSTIC MASTITIS

DR. J. STEWART RODMAN (Philadelphia) said that all physiologists are agreed that ovarian function plays a large part in breast function, and that in hypofunction particularly, but also in dysfunction, breast abnormalities are apt to arise. The work of Hitchmann and Adler, Rosenburg, Polano and Sedening, McFarland, Cheattle and Helen Ingleby amply supports such a point of view. In spite of all this work, however, two important factors still concerned him in deciding upon the proper advice to a given patient. First, when does aberrant physiology become pathology, and secondly, what is the real truth about any association which chronic cystic mastitis may have with carcinoma?

As to the first of these, he called attention to the work and point of view of Helen Ingleby in the pathological laboratory of the Woman's Medical College during the past five years. He, himself, had become a convert to the conservative ranks in so far as this disease is concerned in spite of having been raised in a radical school of thought in dealing with breast lesions in general.

Though others have shown the importance of ovarian function, to her belongs the credit of insisting that each breast lesion, and particularly the one under discussion, must be considered in the light of the known cycle of the mammary gland. The histological appearances differ considerably in the various phases that go to make this cycle.

In fact, the clinical findings also vary so that whatever else one may know about the patient, one must know whether one is dealing with the pre-menstrual, menstrual, post-menstrual or resting phase of the gland. To further complicate this matter, the histological appearances of the structures going to make up a benign solid tumor, for example, will often go hand in hand with those in the gland itself, so that what is often taken to be an added epithelial activity is in reality nothing more than what one would expect because of what is happening to the gland itself in the particular phase of its activity. Those interested in this most important part of the problem were referred to a paper by Helen Ingleby on the relation of fibroadenoma and chronic cystic mastitis to sexual cycle changes in the breast, about to appear in the *Journal of Cancer*.

There is, however, a time when in some of these instances of aberrant physiology one begins to deal with the pathological and, therefore, cannot

afford to any longer give conservative advice. It may be assumed that the same hormone which produces the harmless tissue aggressions and retrogressions of the menstrual cycle will in certain cases, usually associated with some type of ovarian dysfunction, produce locally a fibroadenoma, or, more generally, a chronic cystic mastitis. It seems to be the same process with these variations of the theme.

In so far as the second important problem is concerned, it does not yet seem settled as to what is the relationship, if any, between chronic cystic mastitis and carcinoma. It is agreed that the term "pre-cancerous" should no longer be used in describing chronic cystic mastitis. Certainly, most of those who have chronic cystic mastitis will not develop cancer, but some will. As yet he could find no certain way to distinguish between the two. The term "pre-cancerous" should, however, be abandoned because it accentuates something which does not happen as a rule. In agreeing to do away with it one must not forget to think always of the possibility of cancer. Cheatle, in his recent monograph with Cutler, on the breast, states that the condition which he calls "cystipherous desquamative epithelial hyperplasia" may go on to carcinoma, and he has been quoted elsewhere as stating that he believes this to happen in about 20 per cent. of the cases. This was about his own experience if by cystipherous desquamative epithelial hyperplasia he means that type of chronic cystic mastitis associated with cyst formation and epithelial activity, the papillary and adenomatous groups of Warren's original classification.

Just why the epithelial hyperplasia of chronic mastitis, in the majority of instances, stops short of carcinoma remains for future workers to show. The recent work of Hammett in Reiman's laboratory proving that at least one of the activators of epithelial growth is SH radical is interesting. There must be other factors involved, however, as continued stimulation by the SH radical leads always to higher differentiation of cells while carcinoma goes the other way and always represents a group of undifferentiated cells.

Clinicians, however, must, while waiting for these problems to be finally solved, have some sort of working rule to guide them in dealing with chronic cystic mastitis, or abnormal involution of the breast. In their newly found conservatism, they must not forget that "lumps" in the mammary gland do not normally belong there and that while the majority falling into this group of chronic cystic mastitis are harmless, some are not and should be removed either locally or with the entire breast. In a general way, one will be fairly safe if each of these patients whose age falls into the active sexual cycle of the gland is first placed definitely into the menstrual phase which she shows. Then allow one menstrual period to intervene and see the case again about ten days after the period, or in the middle of the resting phase. If the lump is smaller and less tender, further conservatism is justified. All lumps which do not change, or increase in size, particularly in woman over thirty-five, should then be removed. He did not often do the radical amputation on those with chronic cystic mastitis, but still does it in certain cases in

women over forty where there are multiple small cystic masses in the gland, as it has been his experience so far that every now and again early malignancy is found in this type. Frozen sections are not of much value, as even the pathologists themselves admit, so that one must depend largely on his own and the pathologist's opinion of the gross appearance.

DR. OTTO C. PICKHARDT (New York) remarked that a composite, clinical picture of this lesion could be described thus: The palpating fingers examining a breast in which chronic cystic mastitis has developed would feel, usually in the upper and outer quadrants, a firm, diffuse hardness, filled with numerous shotty nodules. These nodules, which have a definite edge, form larger ill-defined lumps or tumors and are often unusually sensitive. They frequently regress or disappear and are very liable to be bilateral. Intermittent retraction of the nipple may be present. Associated axillary adenitis is by no means constant and is frequently evanescent in character. When it is present the nodes are usually tender and rather soft.

Seventy-six per cent. of the cases of chronic cystic mastitis studied by the speaker grouped themselves in the third and fourth decades, while the incidence of carcinoma of the breast is more common from the fourth decade onward. In other words, chronic cystic mastitis appears earlier in life than carcinoma.

The pathological reports of the Lenox Hill Hospital in 1927-1928 would every so often add, after a minute pathological and cellular description of this lesion, the term "pre-cancerous." On further investigation it developed that there were two distinct schools of thought on this subject—that of Bloodgood, in America, and of Cheatele, in England. Bloodgood felt that chronic cystic mastitis was an essentially benign condition and remained so. Cheatele believed it to be a "pre-cancerous" condition and hence dangerous. With the aid of Doctor Rohdenburg, Director of the Lenox Hill Laboratory, Doctor Pickhardt studied this problem from the theoretical and experimental angle and from the clinical analysis angle.

The investigators received a very definite impression that the type of woman, whatever her age, suffering from this disease, was of the decidedly active kind. They are of the "hyper" rather than of the "hypo" type, and of the alert rather than the phlegmatic. From this it is but a step to the thought that their ovaries are overfunctioning. This condition has been shown by various authors, particularly E. Laquer, C. Ancel, and Leo Loeb, to have a definite effect on the mammary gland. Ancel states: "Corpus luteum induces a proliferation of the mammary gland." Loeb states: "the mammary gland under the stimulus of persisting corpus luteum secretion grows to a considerable size and resembles in character that obtained in pregnancy." These conclusions were drawn from animal experimentation.

An attempt was made to produce chronic cystic mastitis in experimental animals by (1) continuous injections of corpora lutea substance, and (2) *a.*—Ligating parts of the breasts with catgut and silk; *b.*—Injection of a

watery suspension of Kieselguhr into the breast itself. The second part of the experiment was carried out after the animals were well stimulated with the corpora lutea material. The experiments proved that chronic cystic mastitis could be artificially produced.

The animals (mice and guinea-pigs) injected with corpora lutea and without obstruction of the ducts mechanically produced, showed stimulation of the breast without cystic distension and with but slight epithelial overgrowth. Most important, from the standpoint of chronic cystic mastitis being a pre-cancerous condition, one of the mice developed at the point of ligation a definite carcinoma which, at its edges, showed typical chronic cystic mastitis. But a second series of identical experiments yielded no further carcinoma but only chronic cystic mastitis.

The end-result of the speaker's first study could be summed up as follows:

Chronic cystic mastitis can be produced experimentally in mice and guinea-pigs. There were three elements necessary in the development of this lesion: (a) Mechanical stasis; (b) inflammation; (c) proliferative elements due to some epithelial growth stimulation, most logically a specific hormone of the corpus luteum, or graffian follicle, or both.

One animal developed cancer at the site of production.

Chronic cystic mastitis appeared to be a pre-cancerous condition.

The clinical analysis included 117 cases of chronic cystic mastitis, all operated upon; ninety could be traced.

Pathologically, they were divided into two large groups: (a) Simple chronic cystic mastitis, seventy-three; (b) pre-cancerous, seventeen.

The difference in classification between the simple and the pre-cancerous types is based on the following:

"The suspicion of possibly early malignant change or a tendency to malignant degeneration (so-called pre-cancerous) is aroused in those instances where the acini are filled with epithelial cells. Here even serial sections may not always succeed in demonstrating or excluding penetration of the basement membrane." (Rohdenburg.) Of all these, one and one only, clinically has developed into a carcinoma. This case came from the pre-cancerous group.

This case, in which apparently a pre-cancerous chronic cystic mastitis has developed into a carcinoma. February, 1929, a radical mastectomy of the left breast was performed for a tumor the size of a hen's egg. This tumor was movable and the skin was movable over it. Small axillary nodes were present. Microscopical examination of sections obtained from many different parts of the breast showed the picture of a chronic cystic mastitis—some of the ducts and acini were dilated and either lined with multiple layers of atypical cells or completely filled with these cells. Although the lesion was suspicious, there was no definite evidence of infiltrative epithelial growth. Sections of about twelve axillary lymph-nodes showed no evidence of malignancy. By December, 1930, there were well-marked supra-clavicular nodes with lymphœdema of the arm. Clinically the case is now one of carcinoma.

The problem under discussion may be viewed from two separate but connected angles: the almost purely clinical angle, as exemplified by Bloodgood, and the almost purely histological angle, as exemplified by Cheate. Taking the standpoint of the purely histological angle as the first station, the following observations appear to be in order. From the histological standpoint the diagnosis of malignancy is based upon certain deviations from the normal in the architecture of a given tissue. These deviations do not suddenly occur, but are gradual changes which may be traced step by step from the normal to the malignant. The exact point at which a malignant power is assumed by the cells is at all times difficult to determine, and is oftentimes utterly impossible. The histopathologist states that IF this proliferation continues, then it seems logical to suppose that sooner or later the proliferation will become malignant. In support of this viewpoint he cites comparable changes in tissues other than the breast, *e.g.*, the prostate, where such changes are almost invariably followed by malignant degeneration. Against this are the facts that analogous types of proliferation when they occur in the appendix (carcinoids) are clinically but seldom malignant, and the fact that analogous types of proliferation as observed after the injection of Scharlach R in olive oil in animals do not behave in a clinically malignant manner.

In general, the theoretical conclusions would lead one to infer that chronic cystic mastitis is a pre-cancerous lesion.

The histological viewpoint, based as it is on the architectural arrangement of the tissue, must give way to the experience gathered by clinical observation, since clinical experience is the history not of what may, but of what does take place. As shown in the present analysis, clinical observation clearly confirms the standpoint of Bloodgood that the condition is not malignant, and that it does not appear to be the precursor of malignancy at a later date. The few cases associated with malignancy which we have observed much more nearly correspond to the normal cancer rate in a random sample of the same number of females of the general population. We would conclude from our analysis that the condition of chronic cystic mastitis belongs to the same group of proliferative tissue changes as the carcinoid of the appendix. While these bear certain histological resemblances to proliferative processes associated with the development of malignant neoplasms, they actually but seldom pass over the line and become malignant.

Finally, the clinical results as shown by the follow-up in this series, even where only a local excision has been done, are so excellent and so remarkably free from cancer that the speaker has been convinced against his original inclinations and must now feel that chronic cystic mastitis is a benign condition. If it is pre-cancerous it shows that removal in that stage is sufficient to eradicate the cells which tend toward malignancy.

BRIEF COMMUNICATIONS

REMOVING STONES FROM THE DUCTS WITHIN THE LIVER

FIVE methods of removing stones from within the liver have been advocated. They are: (1) The use of a scoop; (2) the use of forceps; (3) the use of irrigation; (4) the use of suction; and (5) incision of the liver and direct removal when the stones are near the surface.

To these methods, I would add another, namely: Stripping and compression of the liver with a hand below and above, making pressure as they are drawn toward the fissure of the liver.

The following cases will illustrate the origin of the idea and its application:

A woman, aged forty years, was admitted to the Methodist Episcopal Hospital of Brooklyn, January 11, 1932. During the two previous years she had suffered from epigastric pain, radiating through to the back, but without jaundice. Twelve days previous to admission she was seized by a similar pain, accompanied this time by jaundice.

After a few days of rest and treatment in the hospital, the jaundice disappeared and an operation was performed. A thick gall-bladder with a few stones was removed and the common duct was found to contain a column of faceted stones, extending from the duodenum to the fissure in the liver. All the palpable stones were removed by expression and the use of a scoop, but the large size of the last stones removed indicated that there must be more higher up in the ducts within the liver. Irrigation proved futile, as did further use of the scoop, so a T-tube was inserted in the common duct, and the wound closed.

Following operation, jaundice recurred and eventually death ensued. At autopsy the common and hepatic ducts were again palpated, but no stones were felt. The liver was then cut loose from all of its attachments and drawn out through the wound, end first, with difficulty and much force. There was much pressure and squeezing of the liver during this process.

As the liver was placed in a pan, four stones were found to have slipped from the opening in the common duct. As they had not been felt in the duct a moment before, we assumed that they had been expelled from the liver by the pressure.

Shortly after this experience another patient was admitted.

A woman, aged forty-five years, entered the Methodist Episcopal Hospital January 27, 1932. She had been ill for two days with pain in the right upper quadrant, vomiting and clay-colored stools. She was deeply jaundiced, her tongue was dry, her pulse was poor and she was dehydrated generally.

After eight days of treatment, with glucose intravenously and fluids in liberal amounts, her jaundice disappeared and she became a good operative risk. At operation there was found a thick-walled gall-bladder, about two-thirds the normal size, and a common duct full of stones.

The gall-bladder was removed and the duct opened and the stones expressed and removed with a scoop. Two stones were felt with the scoop up in the liver, but could not be brought down. Finally they were squeezed down by milking the liver with the left hand below and the right hand placed high up over the dome of the liver and drawn forward with firm pressure.

EXPERIMENTAL PEPTIC ULCER

The fingers behind the hepatic duct easily brought the stones down to the incision in the common duct, after they had emerged from the liver ducts. A T-tube was inserted in the common duct. The patient made a smooth recovery and left the hospital in three weeks.

A limited search of the literature has failed to reveal any report of the use of this procedure. I wish that it might be tried in further suitable cases to determine whether it is of value or not.

HENRY F. GRAHAM, M.D.
Brooklyn, N. Y.

A METHOD OF PRODUCING PEPTIC ULCER EXPERIMENTALLY*

MANN and I, in 1931, described what we believed to be a satisfactory method of making fistulas in the fundus of the stomachs of dogs. During several months of experimentation the results obtained were satisfactory and in accord with those obtained when animals with Pavlov pouches were used. Briefly, the method consists of making a fistula in the stomach of the type described by Mann and Bollman, and later making a pouch of a portion of the stomach drained by the fistula.



FIG. 1.—Pouch of fundus and fistula with ulcer in intestine.

About two months after one of these pouches had been made, the animal died of pneumonia following distemper, and examination of the pouch and the fistula at necropsy disclosed a typical chronic peptic ulcer distal to the suture line in the loop of ileum draining the pouch. (Fig. 1.) Grossly, this ulcer so closely resembled the chronic peptic ulcer of man, and the ulcers which have been produced experimentally by Mann and Williamson and others, that the question immediately arose whether such ulcers would occur in a high percentage of animals following this procedure. Soon thereafter

* Work done in the Division of Experimental Surgery and Pathology of the Mayo Foundation. Submitted for publication, April 18, 1932.

another of these animals died of peritonitis and at necropsy a perforated ulcer of the loop of ileum draining the pouch of the fundus was found. Another animal died after a gradual decrease in weight, and necropsy disclosed a large indurated ulcer with a chronic perforation through the wall of the pouch-fistula into the gastric cavity, with severe localized reaction of tissue and formation of abscess.

In many other animals evidence of ulceration was seen. Perforation with peritonitis and death are not uncommon, although it is rarely seen after the first-stage operation, when the material coming in contact with the mucosa of the small bowel is not pure gastric juice. Bleeding from the fistulous tract, even after such gentle manipulation as passage of a soft rubber catheter, is not uncommon. A few attempts to obtain Röntgen-ray and fluoroscopical evidences of ulceration have not met with success. Direct visualization of the ulcer with a small proctoscope or cystoscope has not, thus far, been very successful. Ulceration has been seen, but with difficulty.

SAMUEL L. GOLDBERG, M.D.,
*Fellow in Surgery, The Mayo Foundation,
Rochester, Minn.*

BIBLIOGRAPHY

- ¹ Goldberg, S. L., and Mann, F. C.: Preparing Pouches of the Fundus of the Stomach. *ANNALS OF SURGERY*, vol. xciv, pp. 953-954, November, 1931.
- ² Harper, F. R.: Unpublished data.
- ³ Mann, F. C.: The Chemical and Mechanical Factors in Experimentally Produced Peptic Ulcer. *Surg. Clin. N. Amer.*, vol. v, pp. 753-775, June, 1925.
- ⁴ Mann, F. C.: The Experimentally Produced Peptic Ulcer. *Am. Jour. Surg.*, vol. vii, pp. 453-454, October, 1929.
- ⁵ Mann, F. C., and Williamson, C. S.: The Experimental Production of Peptic Ulcer. *ANNALS OF SURGERY*, vol. lxxvii, pp. 409-422, April, 1923.
- ⁶ Mann, F. C., and Bollman, J. L.: A Method for Making a Satisfactory Fistula at Any Level of the Gastro-intestinal Tract. *ANNALS OF SURGERY*, vol. xciii, pp. 794-797, March, 1931.
- ⁷ McCann, J. C.: Experimental Peptic Ulcer. *Arch. Surg.*, vol. xix, pp. 600-659, October, 1929.

URETERAL OBSTRUCTION DUE TO SEMINAL VESICULITIS

URETERAL obstruction, due to seminal vesiculitis, was first observed at the operating table by Morgan, in 1902, while operating for ureteral dilatation and hydronephrosis. Young, in 1903, reported complete ureteral obstruction due to seminal vesiculitis, requiring nephro-ureterectomy, and a second case in 1923, relieved by an extraperitoneal operation.

Clinical cases have been reported by Herbst, Mark and Hoffman, Pugh, Barnett, and Von Lichtenberg.

Owing to the increasing interest in the subject during the past thirty years, in the absence of autopsy material the description of a museum specimen from the Department of Pathology of the University of Maryland, is thought worthy of publication. (Fig. 1.)

URETERAL OBSTRUCTION

The seminal vesicles extend along the ureters for two centimetres and are densely adherent to them for two-thirds of their circumference by fibrous adhesions, causing obstruction of each ureter, proximal to intravesicle

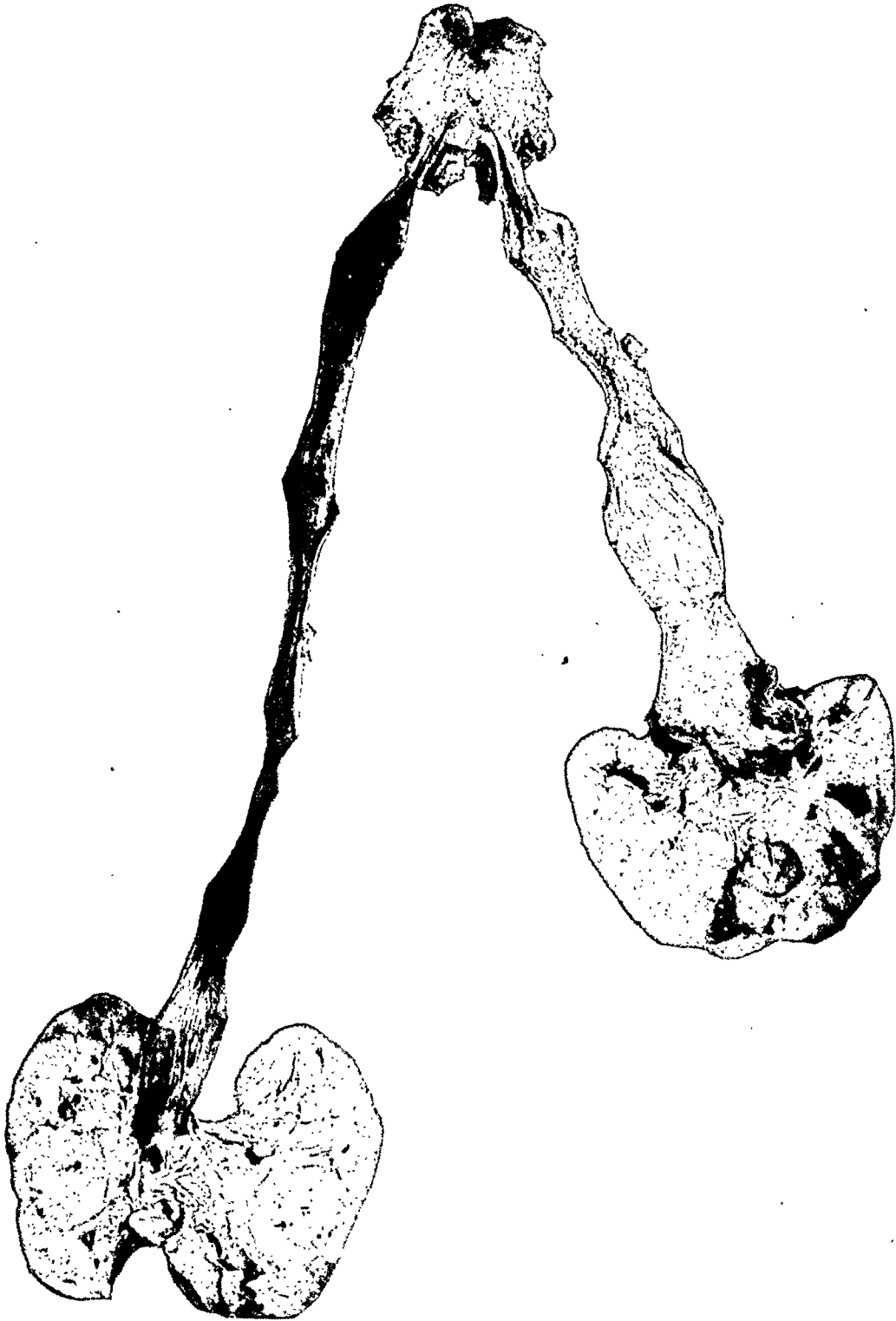


FIG. 1.—Ureteral obstruction due to seminal vesiculitis.

portion with marked dilatation of ureter and kidney pelvis above the tip of the seminal vesicles.

WILLIAM J. CARSON, M.D.
Milwaukee, Wis.

FECAL FISTULA AFTER APPENDECTOMY

THERE appeared in the May issue of the *ANNALS OF SURGERY*, vol. xcy, p. 704, 1932, an article by Dr. James Fairchild Baldwin, "The Prevention of Fecal Fistula after Appendectomy." Controversial points in medicine and surgery should be freely discussed. It seems to me that Doctor Baldwin places too much responsibility upon a simple procedure in technic, namely, the purse-string suture as an important etiological factor in the formation of fecal fistula. The greater part of the mortality and morbidity following appendectomies is not due, as he alleges, to the purse-string suture, but to neglected cases; whether the fault is that of the patient, the general practitioner, or the surgeon himself is not important in this discussion.

We have been teaching for many years that all exposed surfaces be peritonealized. This is exactly what the purse-string suture accomplishes. It makes very little difference whether it is used in burying an appendiceal stump, a perforation, the exposed surfaces after a hysterectomy, or a line of intestinal suture such as we find in the anastomosis of the viscera, one to another. To say dogmatically that the purse-string suture is all wrong will only lead to carelessness in operations other than appendectomy.

It has not been my experience that the inverted appendix acts as an incubator. I, too, have had occasion to open the abdomen years after I had performed an appendectomy. It was most difficult to find evidence of any reaction at the site of operation. There was never any semblance of infection having taken place, nor were there any serious adhesions. Even in those cases where I was compelled to open the abdomen upon the insistence of the patient to look for adhesions, nothing was found to account for the symptoms.

An appendiceal stump free in the abdomen will certainly be more liable to distribute infection than one that has been covered by peritoneum.

Carbolic acid is not as effective a cauterant as the actual cautery. Not the "tip of the cautery" but the flat surface of the instrument is used.

After many years of active surgical experience I have learned that it is impossible to lay down hard-and-fast rules concerning any operation, and this is no less true of the procedure of appendectomy. While I use the purse-string suture in 98 per cent. of the cases operated upon, there are exceptional cases where it should not be used. Where the appendix is bathed in a pocket of pus, where the base of the appendix is gangrenous, or where the cæcum is hard and indurated, inversion of the appendix is foolhardy and dangerous.

I have never in my experience encountered a fecal fistula as a result of the purse-string suture. The only fistulæ seen were those following perforative, gangrenous or suppurative appendices located near the head of the cæcum.

The chief objections as stated by Doctor Baldwin are: (1) That the purse-string suture consumes more time; this should not be considered when any simple appendix can be removed in four or five minutes. (2) I cannot agree that the cæcum must be mobilized to use the purse-string suture be-

cause the suture can be performed on any cæcum with a curved or straight needle. (3) The danger of penetrating the bowel is reduced to a minimum when the needle is introduced properly and with care. I have never seen any leakage around the site of needle puncture. (4) A hæmatoma may result occasionally, but this is a minor matter, since a hæmostat and a ligature will control it. (5) I have never seen necrosis of the cæcum following a purse-string suture. (6) Post-operative adhesions are no greater after this procedure than when the appendix is left free in the abdomen. (7) Fecal fistulæ do not result from the purse-string suture, but from neglected cases of appendicitis. (8) The so-called incubation chamber of the buried stump is no more dangerous than the infected stump lying free in the abdominal cavity.

In the removal of the appendix I use the incision best suited to the case, including the McBurney incision.

MOSES BEHREND, M.D.
Philadelphia, Pa.

OBTAINING LIVING FASCIAL SUTURES

THE introduction of the use of the living fascial sutures by Gallie and Le Mesurier¹ in 1923 marked a very important advance in the treatment of hernia caused by defect in muscle and fascia, namely: recurrent hernia, direct

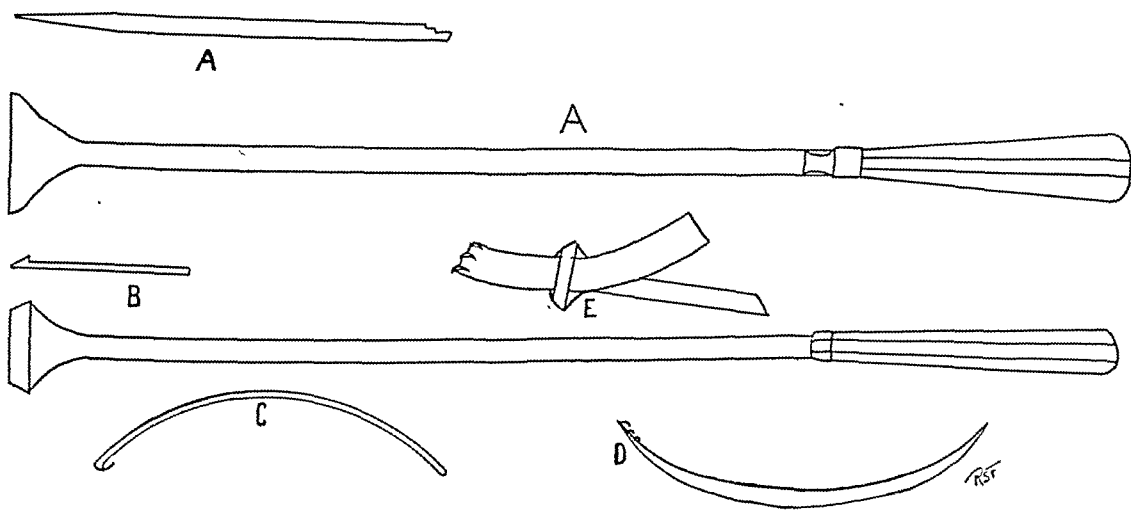


FIG. 1.—A—Fuld's fascial separator (side and top views). B—Grace's fascial stripper (side and top views). C—Fuld's fascial threader. D—Gripper end of threader. E—Threader in stripper.

hernia, ventral hernia and old oblique inguinal hernia in patients past middle age. The Gallie¹ operation, which is admittedly superior to older operative methods for these conditions, is, however, frequently refused by the patients because of the long scar which invariably results from the removal of the fascia. The Gallie operation is also accompanied by an increased period of disability, and by infection in some cases.

These objections have been largely overcome by the use of the fascial stripper devised by R. V. Grace.² Because of the density of the overlying

¹ Gallie and Le Mesurier: Living Sutures in the Treatment of Hernia. *Canadian Ass. Jour.*, July, 1923.

² Grace, R. V.: A Facial Stripper. *ANNALS OF SURGERY*, December, 1929.

BRIEF COMMUNICATIONS

subcutaneous tissue, considerable technical difficulty is frequently encountered in removing the fascia with this stripper. In modifying the technic suggested by Grace, and by the use of two additional instruments (Fig. 1) which I devised, I have been able to remove the fascia more easily with the stripper and more quickly in a series of twelve cases in the past two months. A description of the method below is offered in the hope that it may be helpful to others.

Technic.—Make a two-inch longitudinal incision on the outer aspect of a thigh beginning at the level of the upper border of the patella. I prefer a longitudinal incision because the direction of the fibres of the fascia is more easily seen. Carry the incision to the fascia and dissect the latter free from the subcutaneous tissue with a scalpel about an inch on either side.

The next step is to separate the subcutaneous tissue from the strip of fascia which is to be removed. This is accomplished with the "fascial separator" which is constructed as a large-size fascial stripper but differs from it inasmuch as the cutting end is replaced by a solid piece, with an edge that is not sharp. This instrument is held at an angle of 20 degrees with the thigh along the direction of the fibres of the fascia in the plane of cleavage between the latter and the subcutaneous tissue. Now incise a strip of fascia in the line of its fibres equal to the width of the stripper and cut it transversely at the lower end where the fascia is always thicker. The strip of fascia is easily threaded in the stripper with the aid of my fascial threader. The fascial threader is a thin, half-curved steel band, half an inch wide and four inches long, and has three small teeth a quarter of an inch from its end. The teeth are engaged in the substance of the cut fascia at the lower thickened end of the strip, which is now threaded into the lumen of the stripper.

This especially designed instrument eliminates the necessity of tying knots which interfere with the process of threading the fascial sutures. It also permits the threading of the fascia in the minimum amount of time with a maximum firmness.

Remove the fascial threader and grasp the free end of the strip with a Kocher forceps. Push the stripper upward holding the Kocher forceps taut. To cut the upper end of the fascial strip, incise the skin and subcutaneous tissue longitudinally over the bulge created by the stripper in the upper part of the thigh. The stripper is then exposed and the attached end of the fascial strip is cut off. The two skin incisions are closed with interrupted silk sutures and a compression bandage is applied.

JOSEPH E. FULD, M.D.,
New York City.

EDITORIAL ADDRESS

The office of the Editor of the *Annals of Surgery* is located at 131 St. James Place, Brooklyn, New York. All contributions for publication, Books for Review, and Exchanges should be sent to this address.

Remittances for Subscriptions and Advertising and all business communications should be addressed to the

ANNALS OF SURGERY
227-231 South Sixth Street
Philadelphia, Penna.

ANNALS *of* SURGERY

Vol. XCVI

AUGUST, 1932

No. 2

PENETRATING WOUNDS OF THE ABDOMEN *

REPORTING SIXTY-THREE CASES

RECEIVED FROM PISTOL, RIFLE AND SHOTGUN MISSILES

By BYRD CHARLES WILLIS, M.D.

OF ROCKY MOUNT, N. C.

PENETRATING wounds of the abdomen, even without injury to its contents, are quite dangerous. Except in unusual injuries of the abdominal contents the time elapsing between receipt of the injury and operation is probably the greatest single factor in the recovery of all patients whose injury is not so great as in itself to cause death, as is the case in so many shotgun wounds received at short range. The amount of hæmorrhage and leakage of colon contents, with its secondary peritonitis, are the two great factors which are directly influenced by time.

In treating infections subsequent to perforations of the viscera, the length of time from soiling to operation is of paramount importance. In many of these cases perforation of the colon with escape of fæces has occurred, yet patients will recover if operated upon within two or three hours after receipt of injury. Perforations of the stomach and small intestines, even though received four to six hours before operation, are not very dangerous even when evident localized peritonitis is present. Some of these are closed without drainage, as in perforating duodenal ulcers.

In all cases certain routine treatments should be carried out; these include intravenous glucose and hypodermoclysis of saline, application of heat, prohibiting everything by mouth, antitetanic and perfringens serums, liberal use of morphine for "splinting" the abdomen, and general good nursing. The use of enemas before or after operation in injuries of the lower ileum or colon should not be allowed. The bowels will move, and more safely, without assistance.

This paper is based upon the study of sixty-three cases of perforations of the abdomen admitted to the Park View Hospital and Bass Memorial Hospital to the service of Doctors Boice and Willis, and treated by one or both during the past seventeen years. Many of these were operated upon around midnight. The patients ranged in age from six to sixty-five years, and fifty-four of them were between ten and thirty years of age inclusive. Therefore, the young and robust adult is the usual case treated. There were fifty-five males and eight females. Ten were white and fifty-three were colored. The period of time elapsing between receipt of the injury and admission to the

* Read before The Southern Surgical Association, December, 1931.

hospital was approximately obtained in fifty-one cases, nineteen being received in two hours; twenty-one, between two and five hours; seven, from five to ten hours; four, from ten to fifteen hours; one, thirty hours, and one, four days (abscess due to perforation unsuspected). The loss of time between admission to the hospital and the operation is also a factor in our opinion. Thirty-one of the patients were operated upon within one hour (shortest, five minutes), over one hour and within two hours, twelve; two hours to five hours, six; six to ten hours, two; and one was allowed to remain in the hospital seven days to wall off his abscess. This was the patient that was sent in on the fourth day. Two patients were so moribund that they were not operated upon. In six, the time of the arrival of the patient was not recorded.

The distance and mode of transportation to hospital is important. A few of the cases were from the city; the great majority from a few miles to seventy, the greater number coming from seventeen to forty miles. They were conveyed by automobile, some sitting up and others reclining on the back seat.

We classified this series according to the amount of hæmorrhage, as Mason,¹ of Birmingham, reported a much higher mortality in the large-hæmorrhage group, and we agree with his findings.

	Large Hæmor- rhage	Died	Per Cent.	Total Per Cent.
Pistol shot.....	24	11	46	
Shotgun.....	6	6	100	56.66
	Small Hæmor- rhage	Died	Per Cent.	Total Per Cent.
Pistol shot.....	24	3	12.5	
Shotgun.....	4	0	0	10.71

This complication is more apt to occur in the shotgun wounds inflicted at close range.

We further classified these by the number of perforations of the solid and hollow viscera, considering the point of perforation and its exit as two separate perforations in the hollow viscera, and as one in the solid. Seventeen had one to two perforations; thirteen had three, four and five perforations; twelve had six to ten perforations; ten had over ten perforations, and six were classified as numerous or shotgun wounds. Three abdominal shotgun wounded survived without operations; therefore we are unable to specify the number of perforations. In two, a bullet passed through the abdomen without perforation of organ. One of these had a perforation of right renal vein and died of secondary hæmorrhage twelve hours after operation.

In this series twelve had one organ involved; twenty-five had two; nine had three; eight had four; two had five; five were not operated upon. These included every organ of the abdomen except the suprarenal gland and spleen. One involved the ureter; three the urinary bladder; two the gall-bladder or ducts; many the liver and stomach; many had both colon and small intestines

PENETRATING WOUNDS OF ABDOMEN

at the same time, and a few had one or the other. The pancreas was involved three times. One had three ruptures of an exploded stomach, one of which was about thirteen centimetres in length in the anterior wall (shotgun case). It is not so much the organ involved, excepting the pancreas, but it is the extent of the injury that counts. Pancreatic wounds are more fatal; acute pancreatitis is apt to follow and retroperitoneal hæmorrhage is usually large. Duodenal injuries are particularly difficult to handle because of hæmorrhage obscuring the field of injury and the necessity of mobilizing the duodenum and retroperitoneal infection.

Classification According to Weapon

	Case	Operated	Not Operated	Died	Mortality Per Cent.
Pistol shot.....	47	46	1	15	32
Rifle.....	2	2	0	0	0
Shotgun.....	14	10	4	7	50
Totals.....	63	58	5	22	35

One each of the pistol and shotgun groups were so moribund they were not operated upon; the former died in eighteen hours and the latter in six hours. Three of the non-operative shotgun cases survived.

Classification of Deaths as to Time of Occurrence Following Operation

	Died on Table	Within 48 Hours	After 48 Hours
Pistol shot.....	3	6	5
Shotgun.....	1	5	0

There was only one post-operative obstruction that was operated upon and he survived with an enterostomy. There were other post-operative obstruction cases, both partial and complete, among those that died. Some were recognized, but their condition was so critical that it would not permit interference. Four were enterostomized at time of operation for fear of obstruction, and we think this a very valuable procedure, especially where there are perforations below an anastomosis or too few perforations to justify resection but enough to greatly impair bowel movement.

Only three patients were transfused, but we agree with Mason² that this should be done more often.

The blood-pressure was recorded in twenty-four persons. Of those recorded, five were below eighty millimetres of mercury and nineteen over 100; many of the most desperate cases were not read.

Practically every patient received hypodermoclysis on the operating table, the amount varying from 300 to 3,300 cubic centimetres, and it was kept up after putting them to bed, varying from twenty-four hours to seven days, giving 100 to 200 cubic centimetres an hour. Herndon's intravenous-drip method with 5 per cent. glucose works very nicely in these cases.

Five patients received more than one pistol-shot wound. One developed pneumonia and empyæma; sixteen had a mild peritonitis at the time of

operation; ten had complicating chest wounds, most of these severe, and many died; four had bone fractures, and in twenty-five the bullet or shot lodged in the back. The pulse rate varied from 68 to 170 at beginning of operation, and the great majority were over 100. The upper abdomen was involved in thirty-five; both the lower and upper in three; the lower in twenty-five. Upper abdominal wounds are considered more serious, due to more vital organs and larger blood-vessels. In twelve it was necessary to do an anastomosis of the bowel; in one it was necessary to do two anastomoses, as the bowel was exploded and torn across without actual injury by missiles. This patient was a shotgun case with a large perforation of anterior wall of descending colon with wads and shot in left perirenal space; he survived. He had a temporary fecal fistula. Twelve patients were deliberately not drained, and of these eight lived.

Those that survived operation stayed in the hospital from twelve to fifty-seven days. Practically all received antitetanic serum, and a great many had

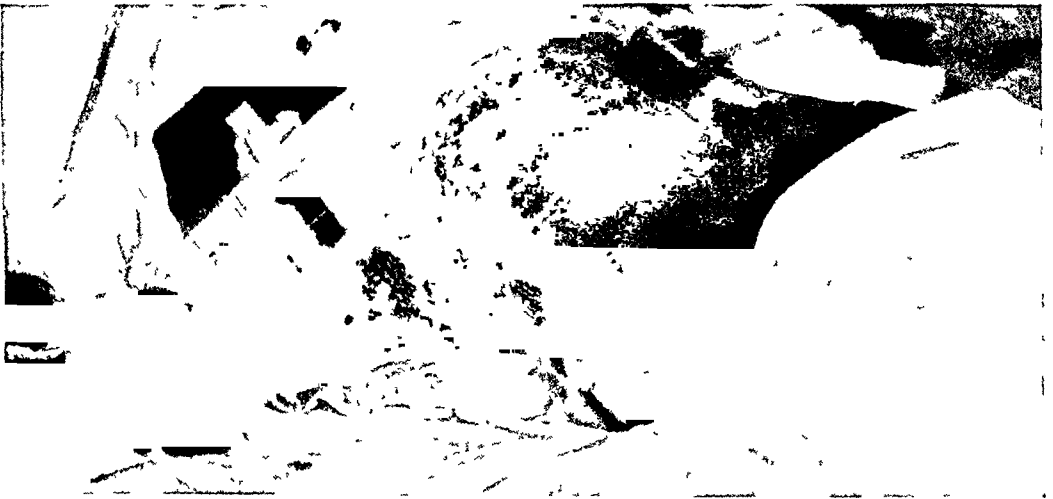


FIG. 1.—External injury from multiple gunshot charge at short range.

antiperfringens. Fifty had ether anæsthesia. Two had ether and spinal anæsthesia; four had spinal anæsthesia alone; two of these died. We do not believe spinal anæsthesia is a safe anæsthetic in these cases. One had local anæsthetic; one did not require any anæsthetic as the opening was so great in the anterior abdominal wall that his insensitive organs could readily be repaired. Two were moribund; and three deliberately not operated upon, believing this was the best treatment. These three are the real basis for reporting this series, and their histories are as follows:

CASE I.—Negro youth, aged sixteen years, admitted to hospital June 27, 1928, stating he had been shot four hours before. He was shot thirty feet from muzzle with No. 4 bird shot, and vomited blood. On examination there were eight shot holes scattered over the abdominal region. Pulse, 75; temperature, normal. He was given antitetanic serum, nothing by mouth, and hypodermoclysis. On the fifth day he was allowed liquid diet and discharged well on the tenth day. Röntgen-ray films were made before his discharge, showing some shot had apparently penetrated the abdomen.

CASE II.—Negro, aged twenty-three years, entered the hospital one hour after being

PENETRATING WOUNDS OF ABDOMEN

shot by 12-gauge gun, No. 6 bird shot, muzzle about nine feet distant and about four feet above him. The load entered the lower border at the right costal margin in nipple line. There were numerous shot holes (Fig. 1), some coalescing, over an area eleven centimetres in diameter. He was not shocked; he had eaten nothing that night. He was not operated upon; was given morphine, $\frac{1}{6}$ grain, every four hours; glucose, 100 grams intravenously on alternate days and nothing by mouth for eight days. Anterior and lateral Röntgen-ray films made about the eighth day showed numerous scattered shot in the right half of the abdomen (Fig. 2) reaching from the costal margin to the symphysis and back in the lumbar region. Colon pus was discharged through shot holes



FIG. 2.—Skiagraph of abdomen of patient shown in Fig. 1, demonstrating the scattered intra-abdominal wounds.

for nearly three weeks. The patient was discharged well on the twenty-ninth day, returning at intervals for several dressings.

CASE III.—Negress, aged fifteen years, was admitted to the hospital 1:30 A.M., September 19, 1931, for shotgun wounds abdomen, chest, left forearm and right thigh. Temperature was 98° F.; pulse, 84. The patient stated that she was sitting in her nightgown on the edge of her bed about 10:30 P.M. "tonight" when she was shot. The gun was 12-gauge and the muzzle was about twelve feet from her. The load passed through the window pane. She was sitting with her right side at about a forty-five-degree angle to the window. Practically three-fourths of the load was received in the right half of the abdomen; a few scattered shot in the chest, breasts, right thigh, and left forearm. (Figs. 3 and 4.) She was carried to the hospital, put to bed, the wounds

dressed with hot packs of boric-acid solution; morphine, 1/6 grain, every four hours was ordered and nothing given by mouth. Hypodermoclysis, normal saline 100 to 200 cubic centimetres every hour started, and 1,500 units of antitetanic and ten cubic centimetres of anaerobic antitoxin given.

By the fifth day her temperature had gradually risen to 103.5° F., reaching normal on the thirteenth day. Her pulse rose to 120 per minute on the second day and remained at that rate with slight variation until the sixth day. Nothing was allowed by mouth until the eighth day. She was given 100 grams glucose intravenously in 1,000 cubic centimetres of distilled water on the third, fifth, seventh, eighth and ninth days. She left the hospital on the twenty-fifth day, apparently well. The abdomen was examined from day to day for peritonitis and abscess.

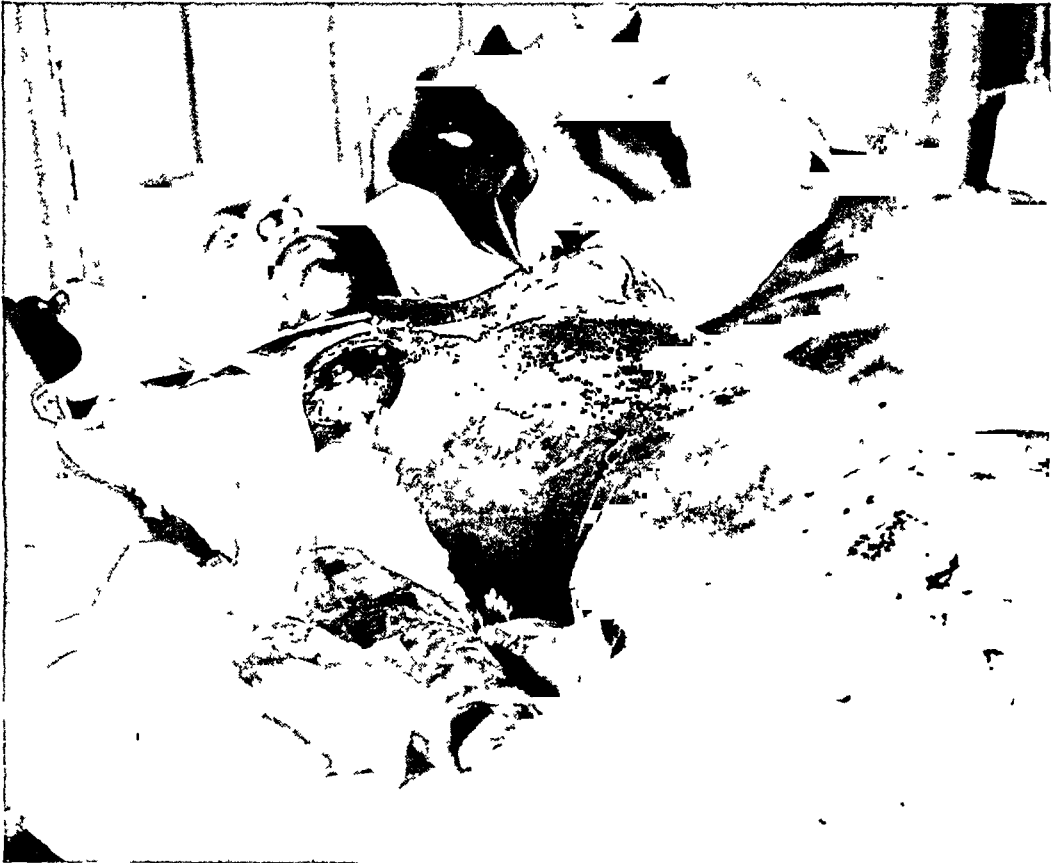


FIG 3—Widely scattered gunshot wounds of abdomen; external appearance

CASE IV.—Negro man, aged fifty years, admitted to the hospital December 12, 1930, with a pistol-shot wound of the abdomen and was operated upon, but died on the table. During exploration of the abdomen two birdshot were found in the liver and one noted in the gall-bladder wall. He no doubt had other shot that were not found. Patient had been previously shot and recovered.

Particular attention is called to the inadvisability of operating upon shot-gun wounds when small birdshot have scattered throughout the abdomen, as it is hopeless and useless to try to locate all the perforations. These perforations are small and, as Bunch³ says, there is no discharge of mucosa through openings. His descriptions are so clear as to the types of wounds, I wish to quote from him as follows:

PENETRATING WOUNDS OF ABDOMEN

Wounds made at a distance, after the pattern of the scattering shot has enlarged and the load is no longer massed, are those of the many individual shot. A small pistol ball may make many intestinal perforations, and a load of scattered shot striking the abdomen may cause numberless perforations. A single shot may pass through the abdomen without penetrating blood-vessel or intestine, but many shot cannot pass through the abdominal wall without injury to the underlying viscera. If the shot penetrating the gut is large, the hole made by it is large, and the everted mucosa pouts through the opening automatically, keeping the wound open and preventing the probability of spontaneous healing. A shot, if it passes longitudinally through the gut-wall, may slit it for an inch or more. If the shot penetrating the intestine is small, the opening made by it may be so small that the mucosa does not pout through the serosa. Such a wound appears as an



FIG. 4.—Skiagraph of abdomen of patient shown in Fig. 3, demonstrating the widely scattered multiple intra-abdominal condition.

elongated pink dot or dash on the gut-wall. The edges fall together in proper apposition and heal readily without surgical help if the gut be kept at rest. Owing to the number of missiles penetrating the abdomen and the vascularity of the viscera, internal hæmorrhage is apt to be free. There are multiple hæmatomas from the mesentery, making particularly difficult the recognition of gut injury.

We would particularly urge that these patients be put to bed with the head of the bed elevated at a 10 to 15° angle; nothing by mouth; morphine sufficient to keep them quiet; hypodermoclysis of saline or intravenous 5 per cent. glucose with proper sterilization and dressing of external abdominal

wound. Tetanus and perfringens serums should be given and a watchful waiting policy followed. If these patients are operated upon, the surgeon will succeed only in milking the infection through the holes in the intestines, greatly shocking the patient, and these efforts will be rewarded by a general peritonitis and death. Bunch, of Columbia, S. C., reported operating upon one of these cases who was in very good condition, and, after closing numerous perforations, gave up the task, realizing that there were many more, and closed the abdomen, and the patient died two hours later.

We have been expecting some of these patients to have secondary abscesses or severe hæmorrhage, and no doubt they will occur and require operation.

The mortality in this series of sixty-three cases with twenty-two deaths is 35 per cent.

BIBLIOGRAPHY

- ¹ Mason, J. M.: *ANNALS OF SURGERY*, vol. lxxix, p. 382, 1924.
- ² Mason, J. M.: *ANNALS OF SURGERY*, vol. lxxviii, p. 364, 1923.
- ³ Bunch, G. H.: *Southern Surg. Trans.*, vol. xli, p. 38, 1928.

THE INFLUENCE OF HÆMORRHAGE IN ABDOMINAL GUNSHOT INJURIES

BY FRANK L. LORIA, M.D.

OF NEW ORLEANS, LA.

FROM THE DEPARTMENT OF SURGERY OF THE TULANE UNIVERSITY SCHOOL OF MEDICINE
AND THE NEW ORLEANS CHARITY HOSPITAL

IN 1925, the New Orleans Charity Hospital Surgical Staff, at the suggestion of Dr. Rudolph Matas, appointed a committee to study all cases of abdominal gunshot injuries admitted to the hospital and to report on the subject at the end of the year. Professor Matas was named chairman of this committee and the writer secretary. It became the duty of the secretary to observe all cases admitted to the hospital for treatment, to follow, if possible to do so, their progress while in the hospital as well as after leaving the hospital in the event of recovery, and to observe and record all autopsies on the fatal cases. The latter became possible through the kindness and courtesy of the New Orleans Parish Coroner, Dr. George F. Roeling, who rendered invaluable coöperation during the period of study. The study extended over the years 1925 and 1926. After the cases admitted during the first five months of 1927 had been observed, it became necessary to discontinue the work. However, during the period named, 137 cases of abdominal gunshot injuries were treated at this institution, eleven died at the scene of the shooting, and the author has added five cases treated at Hotel Dieu (one case), Touro Infirmary (two cases), and the Presbyterian Hospital (two cases)—making a total of 153 cases in this series. The author has felt it a duty incumbent upon him to make reports of this study, aside from the reports made to the Charity Hospital Surgical Staff and which were never published. The present communication is concerned chiefly with the types of hæmorrhage observed and the causes of death, as well as the relationship of the one to the other.

In two rather recently published reports the author had occasion to analyze and evaluate the significance of injury to the various abdominal viscera and structures of importance, and later to discuss the factors of prognostic value in abdominal gunshot injuries. The discussion in each instance was based on the detailed study of 112 cases of this type comprising the entire group treated at the Charity Hospital during the years 1925 and 1926. In each of the presentations the very important rôle played by hæmorrhage in these cases was only casually mentioned, it being felt that a discussion involving this phase of the subject might be better given in a future report.

It was not until about July, 1925, that it was decided to classify hæmorrhage seen in these cases into slight, moderate, and massive. From then on the author classified each case as best possible in accordance with this classification. The cases which had already been observed were the most difficult

to classify from this point of view and the greatest number of the "undetermined type of hæmorrhage" group really come from them. Their histories were again reviewed and the records in the coroner's office again consulted for any remarks regarding the amount of blood lost in each case. In a large number of cases the writer observed the amount of blood lost while watching the laparotomy or at the autopsy in the event of a fatality. When it was impossible to observe the operation the operator of the particular case was consulted in regard to this as well as other features concerning the case at hand and the data recorded. The differentiation of the types of hæmorrhage in this series, therefore, is more or less approximate, there being no definite line of demarcation between them. Blood counts were not made because the indications for operation were usually based upon the clinical picture. No laboratory method of any kind was used which might have given a more accurate idea as to the severity of the hæmorrhage. In each case, therefore, the quantity of blood lost was a matter of estimation, the interpretation of which was left to the observation of one of several persons—particularly the operator of the case. The writer realizes and agrees that this was not altogether desirable. However, under the circumstances it was impossible to do otherwise. Again, the personal equation was a matter of great importance and various operators probably interpreted the amount of hæmorrhage in their cases somewhat differently.

No definite amount of blood lost was used as a basis from which to draw conclusions. However, although the amount of blood lost was not measured in any case, the loss of an amount up to 500 cubic centimetres was considered as slight; up to approximately 1,500 cubic centimetres as moderate; and above this the hæmorrhage was looked upon as massive. Each of the cases dying at the scene of the shooting disclosed an abdomen filled with blood at autopsy, with injury to some large blood-vessel. Several presented multiple gunshot wounds. Four of the five cases treated at the above-named private institutions presented massive types of hæmorrhage. In the fifth patient, who died of general peritonitis, the type of hæmorrhage could not be determined.

History of Abdominal Injuries.—One of the earliest references to a penetrating abdominal injury is given by Xenophon in his *Anabasis*. The case was that of a Greek captain who, after being wounded, made his way back to camp holding his bowels in his hands. Various ancient authors tell about the treatment of these injuries, most of which were of course caused by swords, knives, and other sharp or blunt instruments. In most cases the injury was chiefly an evisceration and surprisingly frequently the victim recovered. Gunshot injuries of the abdomen naturally were not seen until after the introduction of gunpowder and its use in firearms, some time during the fourteenth or fifteenth century. At first, the velocity of the bullet being relatively low, the injuries were less extensive. As the type of firearm improved and the velocity of the bullets increased, the wounds became more serious. Guthrie, in 1827, gives an excellent description of the management

of this type of injury during the latter part of the eighteenth and early part of the nineteenth centuries. One of the most popular therapeutic measures during this time and up through the Crimean War in such injuries was bleeding or blood-letting. Since then, however, this practice very rightfully has been discontinued. It was during the Crimean War that Baudens suggested a small exploratory opening into the abdomen to determine the presence or absence of bleeding into the peritoneal cavity. If the sponge was returned without evidence pointing to active bleeding, the cavity was closed, otherwise the opening was enlarged and an attempt to arrest the hæmorrhage made. In a small monograph, published in 1891, Martin and Hare likewise stressed the importance of hæmorrhage in these cases. The early statistics during the World War showed a very high mortality until these cases were handled more thoroughly at the clearing stations nearer the front. Many who might otherwise have succumbed to hæmorrhage were saved by earlier explorations. The loss of blood and the adequate treatment of hæmorrhage have been recognized to be factors of great prognostic importance in the successful treatment of these cases.

In 1918, Fonio called attention to the importance of transfusions in gunshot wounds of the abdomen, the priority of which he ascribes to Agote. Rather recently Mason, in a study of 127 cases of gunshot and other injuries to the abdomen, reasoned that the greatest cause of death in these cases is hæmorrhage. He divided his cases into a "large hæmorrhage series" and a "small hæmorrhage series." The mortality in the former group was 87.2 per cent., and in the latter group 36.1 per cent. This author is convinced that more of these individuals could be saved if transfusions were used more frequently. A few months ago Billings and Walking, in reviewing the experiences of the Pennsylvania Hospital in Philadelphia, from 1909 to 1930, inclusive, outlined briefly the histories of 136 cases of abdominal gunshot wounds. Among them were found fifteen cases showing a slight hæmorrhage, nineteen showing a moderate hæmorrhage, eighty-six showing a severe hæmorrhage, and in sixteen cases the type of hæmorrhage was not given. In the group showing a severe hæmorrhage, fifty-nine, or 68.8 per cent., died, eighteen, or 30.5 per cent., of these being moribund on admission. The remainder—forty-one cases—were judged to be sufficiently good risks for exploration.

Charity Hospital Statistics.—The author believes that, aside from an actual seat of war, no hospital in the world sees and treats as many cases of abdominal gunshot wounds as the New Orleans Charity Hospital. This institution affords the most excellent opportunities for the observation and management of this very serious type of injury. We have here a veritable laboratory wherein a wealth of material not seen at any time except during wartime is almost constantly at hand. From 1900 to 1931, inclusive, there have been admitted for care into this institution 1,299 cases of abdominal gunshot wounds. This figure does not include the cases in whom a diagnosis of non-penetrating abdominal gunshot wound was made, nor does it include a

great number of cases dying during transportation to the hospital or dying in the admitting room as they arrived to be admitted. Among this number, 889 were colored and 410 white victims—a predominance of more than two-to-one in favor of the colored patients. The total number of deaths in this series of 1,299 cases was 807—giving a mortality rate of 62.3 per cent. During these thirty-two years there has been admitted to the institution one case almost every nine days, the average per annum being slightly more than forty cases.

A decennial study of the above figures shows that while the number admitted has increased slightly, each decennium the mortality has kept abreast of the admissions, there being very little variation in the proportion of cases dying.

DECENNium	ADMISSIONS	DEATHS	MORTALITY RATE PER CENT.
1900-1909.....	364	231	63.4
1910-1919.....	402	241	59.9
1920-1929.....	446	290	65.0
1930-1931.....	87	45	51.7
TOTALS 32 years.....	1299	807	62.3

CHART I.—Showing the decennial admission of cases to the New Orleans Charity Hospital since 1900 with the mortality rate for each decennium.

Prior to 1892, abdominal gunshot injuries admitted to this institution were treated conservatively. Practically none of the cases were operated upon. In 1902, Fenner reported 152 cases operated upon at this hospital from 1892 to 1901, inclusive. This author included stab wounds in the series and expressed himself in favor of exploring cases of penetrating wounds of the abdomen if they were seen sufficiently early. The mortality in this group of cases was 57.23 per cent. Apparently, the mortality increased later because a period followed during which relatively few operations were performed. It appears that only a small number of cases were operated upon up to 1914, following which explorations again seemed to be the preferable routine. Lately the loss of blood as a factor in the prognosis has come to be considered as very important. Until recently relatively few patients were given transfusions. However, during the past few years it appears that more have received this form of therapy.

Causes of Death.—Generally speaking, the two main causes of death in abdominal gunshot injuries are (1) extensive hæmorrhage associated with shock, and (2) general peritonitis. Other complications, such as subphrenic abscess, gangrene of a segment of intestines, pulmonary embolism, *etc.*, form a considerably smaller group—less than 8 per cent. of the sixty-eight fatalities among the 112 cases previously reported. In that group of deaths, 92.6 per cent. died of hæmorrhage and shock (54.4 per cent.) and general peritonitis (38.2 per cent.). Subcutaneous injuries to the various abdominal viscera cause death in more or less the same way. However, in the latter type of

injury true shock from trauma appears to be a more conspicuous factor than in gunshot wounds. On the other hand, stab wounds and even cases of severe impalement appear to show less shock than gunshot wounds. This was very interestingly observed recently in an unusual case of abdominal injury by impalement reported by Sutherland. The existence of true shock, otherwise than from hæmorrhage in abdominal gunshot wounds, has probably been overemphasized. My observations on these cases impress me with the fact that the extent of shock varies with the amount of hæmorrhage and is proportional to it. This influence of hæmorrhage on shock has lately been carefully studied by a number of investigators. Phemister and Blalock were convinced, following severe trauma to an extremity of their experimental animals, that the reason for the shock was the loss of blood into the traumatized tissues. Blalock has also repeatedly produced shock by removing large amounts of blood from the experimental animal. The greater the hæmorrhage the more severe the shock, and those animals losing the largest amounts of blood responded proportionately less favorably to the various therapeutic measures no matter how soon the treatment was begun. In this series of 153 cases, also, the greater the quantity of blood lost by the victims the more severe the shock and the worse the prognosis.

Among the 153 cases there were 100 fatalities or a mortality of 65.3 per cent. This mortality of course included eleven cases dying at the scene of the shooting, and which might rightfully be eliminated for the time being. Without them the mortality rate on the 142 cases receiving hospital attention would be 62.6 per cent. Analyzing the causes of death in this group it will be seen that fifty-five cases, or 55 per cent., of the total died of hæmorrhage and shock, thirty-four cases died as the result of general peritonitis, while only eleven cases died from all the other causes combined. The first two factors, therefore, accounted for 89 per cent. of the fatalities. The other 11 per cent. died of subphrenic abscess (one case), gangrene of a segment of bowel associated with septicæmia (four cases), pulmonary embolism (one case), intestinal obstruction (two cases), and one case each of respiratory failure, acute gastric dilatation, and bronchopneumonia with peritonitis. Hæmorrhage in the majority of cases is, therefore, directly responsible for a fatal issue. However, it is the author's belief that this factor also influences greatly a fatal termination attributable to other causes, being more or less indirectly responsible for a great many of the other deaths, especially many of the cases dying of general peritonitis.

The loss of blood is undoubtedly the most influential factor concerned in the outcome of abdominal gunshot injuries. Mason has also arrived at the same conclusion. It is true also of the present series among which twenty-one cases showed a slight hæmorrhage, forty-two a moderate hæmorrhage, sixty a massive type of hæmorrhage, and in thirty the type was not determined. A further study of the statistics reveals that the mortality rate in this series of 153 cases increased with the quantity of blood lost. Accordingly, in the first group, *i.e.*, with slight hæmorrhage, there was a mortality rate of 28.57 per

CAUSES OF DEATH	HÆMORRHAGE			
	Slight	Moderate	Massive	Undetermined
Abscess—subphrenic.....	0	0	0	1
Pneumonia and peritonitis.....	0	1	0	0
Gangrene and septicæmia.....	0	2	2	0
General peritonitis.....	5	21	2	6
Embolism—pulmonary.....	0	0	0	1
Hæmorrhage and shock.....	0	0	52	3
Acute gastric dilatation.....	0	1	0	0
Intestinal obstruction.....	1	0	1	0
Respiratory failure.....	0	1	0	0
TOTALS.....	6	26	57	11

CHART II.—Showing the causes of death in the 100 cases dying compared to the type of hæmorrhage in each group.

cent., in the second group, *i.e.*, those with moderate hæmorrhage, the mortality was 61.9 per cent., whereas the cases with a massive hæmorrhage had a 95.00 per cent. mortality. In the undetermined group in this series there was a mortality of 36.66 per cent., which is of course somewhat difficult to interpret.

In the present series 102 cases were found to have either a moderate or massive hæmorrhage. Among these, eighty-three, or 81.4 per cent., resulted in fatalities. Since the total number of deaths was 100, it results that 83 per cent. of the fatal cases fell in these two groups. A determination of the chief cause of death in these two groups shows that fifty-two of the fifty-seven cases, or 91.2 per cent., dying in the "massive hæmorrhage group," died as the result of hæmorrhage associated with shock. On the other hand, the predominant cause of death among the twenty-six fatalities occurring in the "moderate hæmorrhage group" was general peritonitis, which was responsible for the death of twenty-one, or 80.7 per cent., of the fatal cases in this group. Although the loss of blood, into the peritoneal cavity or elsewhere, lowers the resistance of these patients, the experiments of Sparks and David would appear to indicate that an infection in the peritoneal cavity is not otherwise influenced by the presence of blood. Is it not likely that among these twenty-six fatal cases several might have recovered had it not been for the loss of that quantity of blood which actually made the difference in their resistance to the peritoneal infection? Would all of them have died of general peritonitis if they had lost only a slight amount of blood? There can be but little doubt that the loss of blood is a most influential factor even among the cases dying of general peritonitis.

The greatest cause of death in the "slight hæmorrhage group" in the present series is also general peritonitis, being responsible for five of the six fatalities. However, it is this type of case which has the best chance for recovery as shown by a comparatively lower death rate. Although most of them received injuries to the gastro-intestinal tract, the majority overcame the peritoneal infection. The occurrence of only a slight hæmorrhage in these cases is undoubtedly a very influential factor in their recovery. Among the

ABDOMINAL GUNSHOT INJURIES

group in which the type of hæmorrhage was not determined there were eleven fatal cases—three dying as the result of hæmorrhage and shock and six from general peritonitis. The other two deaths were from pulmonary embolism and subphrenic abscess.

TYPE OF HÆMORRHAGE	TOTAL	LIVED	DIED	MORTALITY RATE
				PER CENT.
Slight.....	21	15	6	28.57
Moderate.....	42	16	26	61.90
Massive.....	60	3	57	95.00
Undetermined.....	30	19	11	36.66
TOTALS.....	153	53	100	65.36

CHART III.—Type of hæmorrhage and mortality in each group.

The Influence of Transfusion.—One of the most difficult problems faced by the operator in the treatment of abdominal gunshot injuries is securing a donor for transfusion. There can be do doubt but that the giving of blood in these cases ranks next in importance to an intelligently planned and rapidly but carefully performed operation that is actually twofold in its purpose—first and most important the securing of bleeding points and second the repair of injuries to the hollow viscera. Unfortunately, the securing of donors in these cases is usually hard. As in all emergencies these cases are rushed to the nearest hospital frequently by individuals who are perfect strangers to them and who usually have no more than a passive inquisitive interest in them. Such individuals as a rule depart very rapidly when asked to give blood to the victim. Frequently, also, by the time the patient's family or friends get to him the blood will do little or no good. These two factors seemed to be rather paramount in the management of the 153 cases making up this series, or rather the 142 receiving hospital care. On the other hand, a great many operators feel that their task is finished as soon as the operation is completed and very little thought and time are given to the post-operative treatment of the case at hand. A great many remain content with the administration of glucose or saline by infusion or hypodermoclysis and fail to take advantage of transfusing the patient—which in the light of our present knowledge is the method par excellence in the treatment of hæmorrhage and even shock. Very often transfusion is not resorted to except as a therapeutic measure of last resort—the period during which it could have done the most good being sacrificed—and the patient succumbs in spite of it. On the other hand, many patients, though conscious upon arrival at the hospital, have lost so much blood that no amount of blood will save them or give them a better chance for life.

In the present group of 142 cases receiving hospital care, only sixteen, or 11.26 per cent., were given transfusions. This is, of course, a very small number from which to draw any conclusions. The majority of these patients were Negroes and at the New Orleans Charity Hospital the greatest difficulty is encountered in securing donors for these individuals. Among the sixteen

cases receiving transfusions one was in the "slight hæmorrhage group," seven in the "moderate hæmorrhage group," five in the "massive hæmorrhage group," and three in the group having an "undetermined hæmorrhage." Further study shows that eight recovered and that four of the fatal cases occurred in the massive hæmorrhage group. If it were possible to make any deductions from such a small number, the giving of blood to these patients would seem to exert a beneficial influence. The author feels as Mason does that more and stronger efforts should be made to secure blood for these victims.

TYPE OF HEMORRHAGE

A	Slight		Moderate		Massive		Undetermined	
	Lived	Died	Lived	Died	Lived	Died	Lived	Died
	15	6	16	26	3	57 *	19	11

Transfusions given—type not being specified.

B	Yes		No		Yes		No		Yes		No		Yes		No	
	0	15	1	5	4	12	3	23	1	2	4	53 *	3	16	0	11

CHART IV. A—Mortality according to the type of hæmorrhage. B—Number of cases receiving transfusions under each type of hæmorrhage—whole or citrated blood.

* Includes cases dying at the scene of the shooting.

SUMMARY.—Abdominal gunshot wounds form one of the most formidable groups of surgical emergencies that the surgeon is called upon to confront. Until well beyond the middle of the nineteenth century bleeding was one of the chief therapeutic measures in the management of these cases, which probably explains, in great part, the mortality of 92.5 per cent. during the Crimean War, according to Lagarde. It appears that the simple matter of discontinuing blood-letting in these cases was sufficient to allow the mortality to drop to 69 per cent. during the Franco-German War even though few if any were explored, and 67.1 per cent. during the Spanish-American War. Today, instead of bleeding, we give blood, and the addition of this therapeutic measure alone seems to have helped reduce the mortality rather materially. This, too, in spite of operative care—although there is no denying the fact that operative interference is the therapeutic measure of first importance. The factor of prime importance, therefore, in these cases, is hæmorrhage. The amount of blood lost by the victim seems to influence, more than any other single factor, the prognosis, the mortality rising proportionately and rather definitely with the amount of blood lost. General peritonitis, which still continues to be a factor of serious consideration in abdominal gunshot injuries, is only second to hæmorrhage and shock among the causes of death. It seems that up to the present time too little attention has been paid to the importance of the loss of blood in these cases. There is no doubt that transfusions are as valuable in these cases as they are in cases of ruptured ectopic pregnancies or hæmorrhage from any other cause.

Conclusions.—(1) The New Orleans Charity Hospital statistics on penetrating abdominal gunshot injuries show 1,299 cases as having been treated

ABDOMINAL GUNSHOT INJURIES

at this institution in the thirty-two years from 1900 through 1931 with a gross mortality of 62.3 per cent.

(2) A series of 153 cases of penetrating abdominal gunshot wounds, 137 of which are from the Charity Hospital, have been carefully observed and studied.

(3) The causes of death in this series have been given and an attempt made to discuss them thoroughly. Hæmorrhage and shock headed the list, having accounted for 55 per cent. of the fatalities, while general peritonitis accounted for 34 per cent. of the deaths. Only 11 per cent. died of other causes in this series.

(4) Hæmorrhage as a rule accounts for most of the shock seen in these cases, the depth of shock being directly proportional to the quantity of blood lost by the victim.

(5) The mortality increases proportionately with the amount of hæmorrhage. Cases losing less blood have a considerably better chance for recovery. The author has divided the hæmorrhage observed, grouping the various cases according to the amount of blood lost.

(6) Transfusions are of indispensable value, second in importance only to operative interference as a therapeutic measure in these cases. Only sixteen of the 142 cases receiving hospital treatment in this series were given transfusions. The mortality among them was 50 per cent.

BIBLIOGRAPHY

- ¹ Xenophon: *The Anabasis*. Book II, Section V. Translation by C. L. Brownson. G. P. Putnam's Sons, New York, 1928.
- ² DeLint, J. G.: *The Treatment of Wounds of the Abdomen in Ancient Times*. *Annals of Medical History*, vol. ix, p. 403, 1927.
- ³ Guthrie, G. J.: *A Treatise on Gunshot Wounds*. Third Edition, printed for Burgess and Hill. Medical Booksellers, London, 1827.
- ⁴ Baudens, M. L.: *Clinique des Plaies D'Armes a Feu*, Paris, 1836.
- ⁵ Baudens, M. L.: *La Guerre de Crimee, etc.*, Paris, 1858.
- ⁶ MacLeod, G. H. B.: *Surgery of the Crimean War*, Richmond, Va., 1862.
- ⁷ Martin, E., and Hare, H. A.: *Wounds and Obstructions of the Intestines*. W. B. Saunders Co., Philadelphia, 1891.
- ⁸ Fenner, E. D.: Report of Six Cases of Penetrating Wounds of the Abdomen Submitted to Abdominal Section. *ANNALS OF SURGERY*, vol. xxxv, No. 1, p. 15, 1902.
- ⁹ Transactions of the Philadelphia Academy of Surgery, Meeting October 7, 1901. Gunshot Wounds of Abdomen. *ANNALS OF SURGERY*, vol. xxxv, No. 1, p. 111, 1902.
- ¹⁰ Fonio, A.: Transfusion of Blood after Gunshot Wounds of Abdomen. *Cor. Bl. D. schweiz. Aerzte.*, vol. xlviii, p. 1719, 1918; *Abst. Jour. Am. Med. Assn.*, vol. lxxii, p. 614.
- ¹¹ Lee, B. J.: Wounds of the Abdomen. *The Medical Department of the United States Army in the World War*. Surgeon General's Report, vol. xi, Part I, p. 443.
- ¹² Mason, J. M.: The Influence of Hæmorrhage on the Mortality in Gunshot and other Injuries of the Abdomen. *ANNALS OF SURGERY*, vol. lxxix, p. 382, 1924.
- ¹³ Bivings, C.: Treatment of Gunshot Wounds of the Abdomen. *Jour. Med. Assn. of Georgia*, vol. xvi, p. 166, May, 1927.
- ¹⁴ Loria, F. L.: Visceral Injuries in Gunshot Wounds of the Abdomen. *New Orleans Med. and Surg. Jour.*, vol. lxxx, p. 282, 1927.

- ¹⁵ Dickinson, A. M.: Treatment of Non-penetrating Wounds of the Abdomen. American Jour. Surgery, vol. ii, p. 43, 1927.
- ¹⁶ Blalock, A., and Harrison, T. R.: The Regulation of Circulation, *etc.* Am. Jour. Physiol., vol. lxxx, p. 157, 1927.
- ¹⁷ Blalock, A.: Mechanism and Treatment of Experimental Shock. Arch. of Surg., vol. xv, p. 762, 1927.
- ¹⁸ Vance, B. M.: Subcutaneous Injuries of the Abdominal Viscera. Arch. of Surg., vol. xvi, p. 631, March, 1928.
- ¹⁹ Phemister, D. B.: The Vascular Properties of Traumatized and Laked Bloods and of Blood from Traumatized Limbs. ANNALS OF SURGERY, vol. lxxxvii, p. 806, 1928.
- ²⁰ Sparks, J. P., and David, V. C.: Effect of Blood in the Peritoneal Cavity upon the Production of Peritonitis in Animals. Surg., Gynec., and Obst., vol. xlviii, p. 780, June, 1929.
- ²¹ Blalock, A.: Experimental Shock. Arch. of Surg., vol. xx, p. 959, June, 1930.
- ²² Loria, F. L.: Prognostic Factors in Abdominal Gunshot Injuries. New Orleans Med. and Surg. Jour., vol. lxxxiii, p. 393, December, 1930.
- ²³ Sutherland, D. M.: An Unusual Abdominal Injury. Brit. Med. Jour., vol. 1, p. 264, 1931.
- ²⁴ Billings, A. E., and Walking, A.: Penetrating Wounds of the Abdomen. ANNALS OF SURGERY, vol. xciv, p. 1018, December, 1931.
- ²⁷ Lagarde, L. A.: Gunshot Injuries, pp. 245-297. New York. Wood, 1916.

PARTIAL AND TOTAL DEVASCULARIZATION OF THE STOMACH*

BY BERTRAM M. BERNHEIM, M.D.

OF BALTIMORE, MARYLAND

IF ONE can reason from analogy, it ought to be possible to reduce the secretions of the stomach by cutting down its blood supply—not that the stomach is essentially a gland like the thyroid, but it serves a double function, not the least part of which is most certainly of the gland type. And not only this, it has an extremely rich blood supply, which, without too great stretch of the imagination, can be likened to that of the thyroid in that it comes in at four points and is most remarkably anastomotic in character. If one can reduce the glandular activities of the thyroid by polar ligations, one ought to be able to accomplish the same thing in the same way in the stomach.

In order to test out this theory the stomachs of eighteen dogs were partially or totally devascularized, with the following results:

1.—Four dogs—lesser curvature, partially or totally devascularized. All animals recovered from the operation.

No. 1.—Died of distemper fourteen months later. Autopsy showed no ulcer or other abnormality connected with the stomach. Twenty-seven Ewald test meals were taken at different times after operation with an average reading of 7 free HCl, 45 combined, 52 total.

No. 2.—This dog is still living (November, 1931) and in good health after twenty-three months. Ten Ewald test meals were given after operation with an average reading of 10 free HCl, 39 combined, 49 total.

No. 3.—Was sacrificed after eight months. No ulcers or other abnormalities were noted in the stomach. Three Ewald test meals taken before operation showed an average of 4 free HCl, 44 combined, 48 total. Three Ewald test meals taken after operation showed an average of 4 free HCl, 36 combined, 40 total.

No. 4.—Was sacrificed fourteen months later at which time a definite ulcer one-fourth inch in diameter was found on its lesser curvature. No other ulcers were noted. Dog had been quite fat and seemed well. Four Ewald test meals taken before operation showed an average of 4 free HCl, 39 combined, 43 total. Four Ewald test meals taken after operation showed an average of 2 free HCl, 65 combined, 67 total.

SUMMARY.—Lesser curvature of stomachs of four dogs partially or totally devascularized. All dogs recovered. One showed an ulcer. Forty-four post-operative Ewald test meals given. Average reading 6 free HCl, 46 combined, 52 total.

2.—Three dogs—lesser and greater curvatures partially devascularized. All three dogs recovered from the operation.

No. 1.—Sacrificed fourteen days after operation because it was so ill. The stomach showed a number of hæmorrhagic areas but no ulcers and no perforation. Two Ewald test meals done after operation gave average of 0 free HCl, 31.5 combined, 31.5 total. Animal was too ill to do any more.

* From the Hunterian Laboratory of Experimental Surgery of the Johns Hopkins Medical School.

No. 2.—Dog had practically the same area of greater curvature devascularized but two vessels instead of one on the lesser curvature ligated, *i.e.*, twice the amount. It recovered and did perfectly well, being sacrificed thirty days after operation to see the result. The stomach looked perfectly normal. No congestion. No ulcers. Four Ewald test meals given after operation gave an average reading of 6 free HCl, 29 combined, 35 total.

No. 3.—Dog had practically same operation done as previous one. It recovered and was perfectly well seven months later when it got lost during the summer. Fourteen Ewald test meals given after operation gave an average reading of 9 free HCl, 40 combined, 49 total.

SUMMARY.—Lesser curvature and greater curvature of three dogs partially devascularized. All three recovered but one was so ill fourteen days post-operative that it had to be sacrificed. Its stomach was seriously congested and probably on the verge of sloughing. Twenty Ewald test meals were given, the average reading being 5 free HCl, 34 combined, 39 total.

3.—Three dogs—lesser curvature totally devascularized. Greater curvature partially devascularized. All three dogs recovered from the operation.

No. 1.—Died of pneumonia fifty days after operation. Stomach showed no ulcers or other abnormalities. Ten Ewald test meals given post-operatively gave average of 6 free HCl, 22 combined, 28 total.

No. 2.—Dog was quite well and under observation for six months, but was lost over the summer. Thirty Ewald test meals given post-operatively gave an average of 3 free HCl, 23 combined, 26 total.

No. 3.—Dog was quite well for six months when it died of intussusception. Stomach showed no ulcer or other abnormalities. Eight Ewald test meals given post-operatively gave an average of 9 free HCl, 30 combined, 39 total.

SUMMARY.—The lesser curvature was totally devascularized and the greater curvature partially devascularized in three dogs, all of which recovered and seemed normal. Stomach showed no ulcers. Forty-eight Ewald test meals were given post-operatively, with an average reading of 6 free HCl, 25 combined, 31 total.

4.—Three dogs—greater curvature totally, lesser curvature partially devascularized. All three recovered but died early after operation from distemper.

No. 1.—Died of distemper twenty-four days after operation. There was some mottling of gastric mucosa but no ulcers. Stomach contents were not blood-stained. Three Ewald test meals given post-operatively showed an average of 11 free HCl, 45 combined, 56 total.

No. 2.—Sacrificed five days after operation because it had bad case of distemper. Stomach showed an occasional pinhead-sized dusky area in mucosa but nothing else. Contents were not bloody. No post-operative readings.

No. 3.—Sacrificed thirteen days after operation because of distemper. Stomach showed slight hyperæmia of mucosa and perhaps a slight fullness of rugæ, but nothing else. Four Ewald test meals given post-operatively gave average of 12 free HCl, 66 combined, 78 total.

SUMMARY.—The greater curvature was totally devascularized and the lesser partially devascularized in three dogs, all of which got distemper and either died or had to be sacrificed within twenty-four days after operation. Slight hyperæmia of gastric mucosa was noted, but nothing else. Seven Ewald test meals gave an average of 8 free HCl, 37 combined, 45 total.

(The question arises as to whether these three experiments should not be thrown out of the study—until they can be repeated.)

5.—Five dogs—both curvatures—totally devascularized. Four died. One recovered but was lost track of.

No. 1.—Sacrificed seven days after operation because it was so ill. Autopsy showed roughly one-half of stomach gangrenous, the greater curvature being the part involved.

STOMACH DEVASCULARIZATION

The lesser curvature seemed uninvolved. One Ewald test meal showed 0 free HCl, 30 combined, 30 total.

No. 2.—Died three and one-half days after operation. Autopsy showed abdomen filled with bloody fluid and large irregular perforation on anterior surface of stomach near edge of greater curvature. Rest of stomach not affected. No Ewald test meals given.

No. 3.—Died six days after operation. Autopsy showed greater curvature gangrenous and throughout one-third of its extent digested. Large amount of thick, bloody fluid in peritoneal cavity. No test meals given.

No. 4.—Died one and one-half days after operation. Autopsy showed greater curvature gangrenous and digested throughout one-third of its extent, with some thick, bloody fluid in the peritoneal cavity. No Ewald test meals given.

No. 5.—Dog was living ten days after operation, at which time Ewald test meal showed 14 free HCl, 42 combined, 56 total. Seven days later test meal showed 16 free HCl, 72 combined, 88 total. After that it was lost. Average for two Ewald test meals was 15 free HCl, 57 combined, 72 total. But three tests pre-operatively showed average of 27 free HCl, 34 combined, 61 total.

SUMMARY.—Total devascularization of stomach in five dogs resulted in death of four. In the one that survived it would seem that at least one major vessel was not ligated.

With regard to evaluating the readings obtained from the various test meals I feel that only the first three series of dogs can be considered since the fourth series all came down with distemper soon after operation and had to be sacrificed, and in the fifth series all (except the one) died so promptly from gangrene of the stomach that practically no tests could be made.

In order to determine as far as possible the average reading on the normal dog in our laboratory living under the usual conditions of the institution, food and all, we gave seventy-one Ewald test meals to fourteen different animals and got an average reading for the total of 5 free HCl, 36 combined, 41 total.

If we compared to this the average reading (forty-four tests) of the three dogs of Series I, where the lesser curvature was either partially or totally devascularized—6 free HCl, 46 combined, 52 total—we find a distinct increase. The second series of three dogs where the lesser and greater curvatures were partially devascularized shows from twenty tests an average reading almost the same as the normal—5 free HCl, 34 combined, 39 total, to 5 free HCl, 36 combined, 41 total.

The third series of three dogs, where the lesser curvature was totally and the greater curvature partially devascularized, shows from forty-eight tests an average reading of 6 free HCl, 25 combined, 31 total, which is a definite decrease.

In each series, whatever difference there was was always in the *combined acids*, though in the individual animals wide discrepancies in the free HCl were noted.

The average for the ten dogs is 6 free HCl, 35 combined, 41 total, which is almost exactly that of the normal.

From these eighteen experiments the following conclusions with regard to the physical aspects of the situation can be drawn:

(1) The stomach (of the dog) can withstand any amount of diminution of its blood supply, whether on the lesser or the greater curvature or on both, short of total devascularization.

(2) The animal either recovers or does not recover. In other words, there is no middle ground where he lives and ekes out a miserable existence.

(3) This being the case, the collateral (compensatory) circulation of the organ must be not only most extensive but most active and effective.

(4) Ligation of blood-vessels does not give rise to ulcers—certainly not macroscopical ones.

(5) Where total devascularization is done, it is the greater curvature that becomes gangrenous, the lesser being unaffected.

From the standpoint of effect on secretion the only definite conclusion that can be reached is that thus far nothing approaching an acidity was found. In this connection it may be said that no conscious attempt was made to deal with the sympathetic nerve fibres going to the stomach, though it is obvious that many of them must have been cut.

In certain animals and in certain groups there seemed to be a slight decrease of acidity but much more work will have to be done in order to be certain about it. In view of the extensive devascularization that was carried out in some of the animals it was most surprising to note that if they lived their stomach went right on pouring out acid much as if nothing had happened. In a way, this, too, is much like what happens following polar ligations in the thyroid gland. There comes to pass a diminution of activity of greater or lesser degree, sometimes rather temporary, sometimes permanent, but it is rare that one can accomplish as much by ligation as by excision.

Just how far the analogy between the stomach and the thyroid can be carried out is a question—one has an idea that, quite aside from the vascular, the nervous mechanism of the two also is much alike—but in any case the comparison is intriguing and may be productive of interesting results. In hyperfunction of the thyroid one can and does excise the major part of the gland, not only with impunity but with great good to the patient. Unfortunately, one cannot remove the stomach with equally happy results—despite the reports of certain enthusiasts. So at that point certainly the analogy will have to cease. Even so—in fact, just because of it—studies of the effects of devascularization of the stomach require further investigation. Many angles of the problem have not even been touched upon here.

This paper is submitted as a preliminary report.

BIBLIOGRAPHY

- Berlet, K.: Ueber die Arterien des Menschlichen Magens und ihre Beziehungen zur Aetiologie und Pathogenese des Magengeschwurs. *Frankfurter Ztschr. f. Path.*, vol. xxx, pp. 472-489, 1924.
- Omato, T.: Experimental Production of Round Peptic Ulcer by Ligation of Various Blood-vessels. *Virchow's Arch. f. path. Anat.*, vol. cclxix, pp. 797-802, 1928.
- Mall, F. P.: The Vessels and Walls of the Dog's Stomach. *Johns Hopkins Hospital Reports*, vol. i, pp. 1-36, 1896.

STOMACH DEVASCULARIZATION

- Jatron, St.: Ueber die Arterielle Versorgung des Magens und ihre Beziehung zum Ulcus Ventriculi. Deut. Zeitschr. f. Chir., vol. clix, pp. 196-223, 1920.
- Lewisohn, R., and Ginsburg, Leon: The Relation of Post-operative Achlorhydria to the Cure of Gastric and Duodenal Ulcers. Surg., Gynec., and Obst., vol. xlv, No. 3, pp. 344-354, 1927.
- Duthie, Robert J.: Variations of Free HCl and Total Chloride in the Upper and Lower Parts of the Stomach. Quar. Jnl. of Med., vol. xxii, No. 88, pp. 578-579, July, 1929.
- Connell, F. Gregory: Fundusectomy. A New Principle in the Treatment of Gastric and Duodenal Ulcer. Surg., Gynec., and Obst., vol. xlix, No. 5, pp. 575-579, November, 1929.
- Hughson, Walter: The Effect of Vagus Neurotomy on the Pyloric Sphincter. Jour. Am. Med. Assn., vol. lxxxviii, pp. 1072-1076, April 2, 1927.

THE VAGUS NERVE AND ITS RELATION TO PEPTIC ULCER

By R. RUSSELL BEST, M.D.

OF OMAHA, NEBRASKA

AND

VICTOR ORATOR, M.D.

OBERARZT, CLINIC OF PROFESSOR VON HABERER, DUESSELDORF, GERMANY

FROM THE DEPARTMENTS OF ANATOMY AND SURGERY, UNIVERSITY OF NEBRASKA

No FIELD of medicine has received more attention from investigators than the relation of peptic ulcer to the neuro-motor and neuro-secretory mechanism of the stomach. The result has been that very few statements have gone unchallenged and most investigations have thrown new shadows into an already clouded picture. The complexity of the literature signifies that we are dealing with a very intricate and difficult problem and only after repeated corroboration of experimental facts can the physiological principles be established.

It is interesting to note the methods which have been employed to produce peptic ulcer: (1) Lesions of the central nervous system. (2) Lesions of the vagus. (3) Lesions of the splanchnic nerves. (4) Direct trauma to the stomach. (5) By local embolic circulatory disturbances. (6) By the ingestion of bacteria. (7) By intravenous injection of bacterial toxins. (8) By injection of adrenalin, silver nitrate, *etc.*, into the walls of the stomach. (9) By intravenous injections of poisons and autolytic toxins. (10) By cutaneous burns. (11) By establishing a pyloric insufficiency and the injection of trypsin. (12) By removal of the adrenal glands.

At many times several methods have been combined. This is particularly true for the production of chronic ulcer. However, no method or combination of methods consistently produces chronic peptic ulcer. With the ease of production of acute ulcer and the difficulty of production of chronic ulcer, there is suggested that the problem divides itself into two phases. The first phase concerns the cause of the initial or acute ulcer and the second phase deals with the chronicity of the lesion. Is the same factor behind the acute and chronic ulcer, except perhaps in a different degree, or does another factor or group of factors enter into the problem of chronic ulcer? As yet, investigators have not been able to answer this question although experimental evidence favors a secondary factor. Friedman and Hamburger¹ produced gastric ulcer by injection of 5 per cent. silver nitrate under the mucosa. These ulcers healed rather rapidly unless the pylorus was partially obstructed, causing retention of gastric secretions. They assumed that an acute ulcer causes spasm and then the retention results in hypersecretion and hyperacidity. This experiment with delayed healing of the ulcer and the deductions which follow would be of more value if the ulcer had caused the pyloric spasm and

retention rather than the operative production of partial pyloric obstruction. Morton² produced acute gastric ulcer by excision of the mucosa and then found that by surgical duodenal drainage whereby the alkaline duodenal contents were not able to influence the gastric acidity and the continuity of the gastro-intestinal tube had been reestablished by anastomoses of the jejunum of the pylorus, that there was delayed healing of the gastric ulcers. This experiment also lends some support to the view that a secondary factor is necessary in establishing chronicity but the experiment is certainly atypical of the normal anatomical physiological relations and merely suggests that the alkaline duodenal secretions aid in healing. Other investigators have produced chronicity of ulcers by introducing a secondary factor but it has been impossible to produce chronic ulcer consistently by means of any method in which the normal anatomical relations of the stomach, pylorus and duodenum have been retained.

A number of investigators have observed lesions of the vagus and medulla oblongata in reporting autopsies of cases with peptic ulcer and have attempted to link this pathology with the ulcer problem. Singer³ found peptic ulcers frequently enough in pulmonary tuberculosis cases where mediastinal involvement was marked to lead him to believe that the vagi nerves had been affected, resulting in stomach ulceration. He also reported cases of meningitis and vagi nuclear changes coincident with peptic ulceration. He also reported cases of vagus neuritis in lead poisoning, where peptic ulceration had been found. Schiff⁴ observed hæmorrhagic infiltration and ulcerations following intersection operation of the thalamus and cerebral peduncles. Oberling and Kallo⁵ claim to have produced peptic ulcer following experimental lesions of various central gray nuclei. Durante,⁶ repeating the work of Vedova Dalla,⁷ produced acute and chronic ulcers by section of the splanchnic nerves. Gundelfinger⁸ after extirpation of the celiac ganglion succeeded in producing gastric lesions. Latzel,⁹ on the contrary, as well as other observers, has reported negative results after extirpation of the celiac ganglion. Finzi¹⁰ and later Keppich,¹¹ among others, have reported atrophic ulceration following resection of the vagus. According to Greggio,¹² Donati, Martini and others described negative results following vagotomy in the neck of rabbits and Krehl, Butsch, Fiosi, Lilla and others reported negative results following vagotomy in the thorax and abdomen. Alvarez,¹³ in the course of some experiments pertaining to bowel motility, observed gastric ulcers in a rather large percentage of rabbits following bilateral vagotomy. As regards changes of the nerves in the stomach wall, Okkel,¹⁴ after carefully examining a large number of stomachs with gastric ulcers, reported there was usually present considerable perineuritis of the nerves adjacent to the ulcer and he considered these changes secondary, but believed they may contribute to the chronicity of ulcers.

The vagus nerve has also been extensively studied regarding its control of the motility, tonus and secretions of the stomach. All of these factors are thought to have some bearing upon the ulcer problem. As in the above-cited

experiments, the investigations have not been uniform. However, we believe one of the most fundamental pieces of work was carried out by McSwiney and Wadge¹⁵ whose results in general are practically accepted. According to them, stimulation of the vagus, regardless of the intensity of frequency, produces inhibition when the tonus is high and contraction when the tonus is low. This suggests a certain degree of autonomy of the stomach wall and is supported by the work of Alvarez in his study of the irritability and rhythmicity of the stomach and intestine after section of the vagi and splanchnics. Alvarez concludes that the gastro-intestinal tube possesses a large degree of autonomy and the neuro-muscular mechanism responsible for orderly diastalsis must be looked for in the bowel itself. Kuntz¹⁶ further established the conception of an intrinsic reflex arc in the wall of the gastro-intestinal tube when he demonstrated a complete arc between Auerbach's and Meissener's plexuses in the cat. Although these investigations practically give conclusive evidence of the autonomy of the stomach wall, there has been no evidence set forth that the stomach is not under the influence of the sympathetic or parasympathetic systems under certain conditions, a factor that must not be forgotten in an investigative or clinical study of peptic ulcer.

A study of the effect of bilateral vagotomy on the emptying time of the stomach would appear to be a rather simple experiment. Yet, very carefully planned and controlled experiments have produced diametrically opposed results. Table I presents this conflicting evidence. An analysis of this work shows that the majority of writers have observed an increase in the emptying time of the stomach after vagi section. After very careful observations,

TABLE I
Emptying time of stomach following bilateral vagotomy

Author	Emptying time		Remarks
	Initial	Total	
Cannon ²⁵	Increase		
Koennecke ²⁶	Increase	Increase	
Latarjet ²⁷	Increase		
Litthauer ²⁸	No change	Increase	
Nieder ²⁹	Possible slight increase		
Stierlin ³⁰	Slight increase	Slight increase	
Watanabe ³¹	Early slight increase	Increase	
Hughson	Marked decrease		
McSwiney, McCrea and Stopford	Marked decrease	Within normal limits	Some animals showed slight increase and others showed slight decrease

Hughson¹⁷ reports a definite decrease in the emptying time. McCrea, McSwiney and Stopford¹⁸ report only a decrease in the initial emptying time. They observed slight variations in the total emptying time ranging from a slight increase to a slight decrease. It is very difficult to account for these variations and evaluate the procedure for clinical surgery.

The results of vagi section on gastric secretion have varied. That the psychic phase of secretion is permanently and entirely abolished has been proven by Pavlov and confirmed by Farrell¹⁹ and others. The influence of the bilateral vagotomy on the gastric phase of secretion has given varied results. Hartzell²⁰ in his experiments upon dogs puts forth evidence that there is a reduction in both free and total acidity. The work of Lim, Ivy and McCarthy²¹ is certainly convincing evidence that the stomach or a pouch completely deprived of vagi innervation responds to both mechanical and chemical stimulation. The clinical results by surgeons who have experimented with vagi section on the human have not been uniform although some encouraging results cannot be denied. This work of Lim, Ivy and McCarthy further supports the conception of the intrinsic nerve reflex and that the true control of gastric motility and secretion is in the stomach wall, yet does not deny the directive influence of the extrinsic nerves.

All of these experiments and observations suggest the possibility that an ulcer having appeared on the mucous membrane either by direct trauma or by temporary disturbance of the neuro-motor or neuro-secretory mechanism of the stomach, the development of chronicity depends upon some trophic element such as a lesion of the central nervous system, the vagi nerves, the sympathetic nerves or a local disturbance of Auerbach's and Meissner's plexuses.

Heineke,²² Pigalew and Buschmakina²³ and later Manenkov²⁴ performed some very interesting experiments on rabbits with production of peritonitis followed by section of the vagi. If the vagi were cut and some weeks later a peritonitis was established by injection of bacteria, an animal with bilateral vagotomy lived much longer or even survived the infection whereas the control rabbits all died within nine to twelve hours. Manenkov further proved that a local severe inflammation of the stomach wall of a rabbit was always fatal while the production of local peritonitis in organs such as the large intestine, uterus, *etc.*, which are not directly associated with the vagus, did not give fatal results.

This latter series of experiments suggested to us that possibly the presence of a neuro-lymphatic connection between the stomach, vagi nerves and medulla might explain the chronicity of certain lesions of the stomach. It was assumed that a primary traumatic ulceration or inflammation beginning in the stomach wall would result in pathological changes of the vagi nerves or various nuclei in the medulla oblongata. Therefore, the following experiments were performed in the hopes that such a pathological relationship could be established.

The stomach walls of ten rabbits were injected with a suspension of *staphylococcus aureus* and after death an autopsy performed and sections

taken from the medulla, cervical vagi, thoracic vagi and stomach for microscopic examination. Sections were taken from the sciatic nerves to serve as control nerve tissue. The amount of injected material was slightly varied on several occasions. The life of the animals varied from sixteen to forty-eight hours. Below is the description of a typical experiment:

Full grown rabbit. Laparotomy performed and 2 cubic centimetres of a 1/100, twenty-four-hour old staphylococcus aureus culture in normal saline injected under the serosa of the anterior wall of the stomach near the lesser curvature. Eighteen hours later the animal died. At post-mortem examination there was no evidence of general peritonitis. There was a marked inflammation of the stomach wall at the site of injection, an area about 1½ centimetres in diameter. Under this area and somewhat more extensive, the mucosa was injected and numerous small, dark, discolored areas were found. Some of these showed early ulceration. The medulla oblongata, segments of cervical and thoracic vagi, segments of the sciatic nerves and a portion of the stomach were removed for microscopic examination.

It would be only repetition to give the protocols of the remaining nine rabbits, since the course of the infection was the same in every experiment except for the degree of reaction and later death that occurred in the animals receiving the lesser amount of staphylococcus culture. It was remarkable how innocent the infection on the stomach wall appeared, and yet all of the animals died within forty-eight hours. There was no attempt made to repeat the experiments of Manenkow to prove whether or not section of the vagi prolonged life, since the object of our own experiments was to demonstrate pathological changes in the vagi nerve or central nuclei, which might account for chronicity of lesions of the stomach wall.

Serial sections were made from the medulla of each rabbit. There were no definite consistent pathological changes found. A few sections showed some very minor pathological changes, such as slight vacuolation, slight tygrolisis or a slight decrease in the clearness and sharpness of the nerve-cell body outlines. These changes are probably not significant in view of their indefiniteness and inconsistency. Also in the few sections that did show these changes, there were minor and indefinite changes in the vagi and sciatic nerves of the same rabbit. Both longitudinal and cross sections of the vagi and sciatic nerves were studied. There were no definite constant changes demonstrable. Occasionally there was found a slight swelling of an axis cylinder.

The sections of the stomach showed varying degrees of inflammation with or without ulceration and with or without abscess formation. There was no definite relationship between the degree of inflammation of the stomach wall and the degree of slight changes in the nervous tissue. In other words, severe inflammation of the stomach wall did not necessarily indicate greater changes in the vagi nerves or medulla without corresponding changes in the sciatic nerves. The slight nerve pathology which was seen could be explained easily on a general toxic basis.

With these negative findings which showed absence of definite lesions in the medulla oblongata and vagi nerves following definite inflammatory changes

VAGUS NERVE AND PEPTIC ULCER

of the stomach wall which were sufficient to cause death, it is rather difficult to assume that acute lesions of the stomach wall produce changes in the vagi or medulla oblongata which would result in chronicity of an initial lesion such as gastric ulcer.

Since we were unable to establish a pathological relationship between the vagi nerves, vagi nuclei and stomach with the primary lesion in the stomach, we concluded that the next procedure was to produce a chronic irritation of the vagus and note the pathological changes that might occur in the stomach.

Ten dogs were used in this set of experiments. In the first two animals, the experiments were carried out in the following manner: A blind pyloric pouch was made by sectioning the duodenum just beyond the pylorus and closing both ends of the duodenum. The stomach was then sectioned about two inches proximal to the pylorus. The pyloric portion was sutured to the skin, giving a blind pyloric pouch and fistula. The fundic end of the stomach was then anastomosed to the side of the descending portion of the duodenum. After allowing about two months for complete healing to take place, both vagi in the neck were exposed and about two inches of magnesium strips were wrapped around the nerves and the wound closed tightly. Both of these dogs died on the fourth day after operation. The autopsy findings were negative, not only as regards the examination of stomach, duodenum and pyloric pouch, but also as regards the cause of death. We attributed the cause of death to the vagus inhibitive action upon the heart. To further substantiate this hypothesis and also to help establish the fact that we were actually irritating the vagi, magnesium was wrapped around the vagi nerves of two dogs without a previous stomach operation. As expected, both dogs died on the fourth day. It was then apparent that we must either put magnesium only upon one nerve in the neck or upon both vagi in the region of the diaphragm. We assumed it better to use one vagus in the neck because the branches of the vagi are rather small and delicate in the region of the diaphragm. Also, there existed the possibility that the magnesium might act as a direct irritant on the stomach wall and thus defeat the purpose of the experiment. Strips of magnesium were then wrapped around the right or left vagus of six dogs. At periods varying from one month to four months after the vagus operation, the abdomen was opened and the stomach and duodenum were carefully examined. No ulcer of the stomach or of the duodenum was found in any case. At this time in each animal, a pyloric pouch with a fistula was made and the proximal section of the stomach sutured to the side of the duodenum. This type of operation offered the opportunity for direct examination of the mucous membrane surfaces of a pyloric pouch at repeated intervals. None of these animals showed evidence of acute or chronic gastric or duodenal ulcer. The animals died or were killed in periods ranging from one month to six months after this second operation. The pyloric pouch, the stomach and the duodenum were closely examined and particular attention was given to suture lines. There was found no evidence of an acute or chronic gastric or duodenal ulcer and no delay was observed in the healing process along the former suture lines.

Summarizing these experiments, we have attempted to produce definite changes in the vagi nerves or medulla oblongata by a rather active inflammation in the wall of the stomach, hoping that such pathological changes could be proven later to be a factor in the chronicity of peptic ulcer. Definite and consistent changes were not demonstrable. Since these findings were negative it was believed that the experiment would not be complete until it was proven that a known irritant of the vagi nerves, such as magnesium strips, would or would not produce acute or chronic gastric or duodenal ulcer.

Rather long-drawn-out experiments of this nature did not result in peptic ulceration of the stomach or duodenum or delay the process of healing.

Conclusions.—(1) The results are rather convincing that lesions of the stomach do not result in organic changes of the vagi and medulla through a direct neuro-lymphatic connection.

(2) Direct continued irritation of the vagus with a known irritant such as magnesium does not produce acute or chronic gastric or duodenal ulcer and does not prolong healing.

(3) This is supportive evidence that section of the vagi nerves for the treatment of peptic ulcer will prove to be of little value.

NOTE.—The author acknowledges with sincere gratitude the valuable aid rendered to him by Herr Doctor E. Spiegel, of the Neurological Institute of Vienna.

BIBLIOGRAPHY

- ¹ Friedman, J. C., and Hamburger, W. W.: Experimental Chronic Gastric Ulcer. *J. A. M. A.*, ol. lxiii, p. 380, August 1, 1914.
- ² Morton, C. B.: Experimental Produced Peptic Ulcer. *ANNALS OF SURGERY*, vol. lxxxv, p. 207, 1927.
- ³ Singer, G.: Rôle of Affections of Vagus in Development of Gastric Ulcer. *Archives für Verdauungskrankheit.*, vol. xliii, p. 410, March, 1928.
- ⁴ Schiff, J. M.: Lecons sur la physiologie de la digestion. Florence H. Loescher, vol. ii, p. 557, 1867.
- ⁵ Oberling, C., and Kallo, A.: Acute Ulcers of Stomach Following Experimental Lesions of Central Gray Nuclei. *Comp. rend. Soc. de biol.*, vol. cii, p. 833, December 13, 1929.
- ⁶ Durante, Luigi: The Trophic Element in the Origin of Gastric Ulcer. *Surg., Gynec., and Obst.*, vol. xxii, p. 399, 1916.
- ⁷ Vedova, R. D.: Recherche sperimentali sulla patogenesi dell'ulcera gastrica. *Poleclinico*, vol. vi, p. 1153, 1900.
- ⁸ Gundelfinger, Ernst: Klinische und experimentelle Untersuchungen über den Einfluss des Nervensystems bei der Entstehung des runden Magengeschwurs. *Mitt. a. d. Grenzgeb. d. Med. u. Chis.*, vol. xxx, p. 189, 1918.
- ⁹ Latzel, R.: Recherches experimentale sur l'etiologie de l'ulcere de l'estomac et consequences sur la pathogenie de l'ulcere de l'estomac et du duodenum. *J. de chir.*, vol. xi, p. 788, 1913.
- ¹⁰ Finzi, Otello: Ueber Veränderungen der Magenschleimhaut bei Tieren nach Nebennurenexstirpation und über experimental erzeugte Magengeschwüre. *Virchow's Arch. f. path. Anat.*, vol. ccxiv, p. 413, 1913.
- ¹¹ Keppich, Josef: Künstliche Erzeugung von chronischen Magengeschwüren mittels Eingriffe am Magenvagus. *Wien. klin. Wchnschr.*, vol. xxxiv, p. 118, 1921.
- ¹² Greggio, Ettore: Des ulcères gastro-duodénaux. *Arch. de méd. exper. et d'anat. path.*, vol. xxvii, p. 533, 1916-1917.
- ¹³ Alvarez, W. C.: Effects of Degenerative Section of Vagus and Splanchnic Nerves on the Digestive Tract. *Am. J. Physiol.*, vol. xc, pp. 631-655, 1929.
- ¹⁴ Okkels, H.: Pathologic Changes in the Nerves of the Stomach Wall in Cases of Chronic Gastric Ulcer. *Am. J. Path.*, vol. iii, p. 75, 1927.
- ¹⁵ McSwiney, B. A., and Wadge, W. J.: Effects of Variations in Intensity and Frequency on the Contractions of the Stomach Obtained by Stimulation of the Vagus Nerve. *Journ. Physiol.*, vol. lxxv, p. 351, 1928.
- ¹⁶ Kuntz, A.: On the Occurrence of Reflex Arcs in the Myenteric and Submucous Plexuses. *Anat. Record*, vol. xxiv, p. 193, 1922.

- ¹⁷ Hughson, W.: The Effect of Vagus Neurotomy on the Pyloric Sphincter. J. A. M. A., vol. lxxxviii, p. 1072, 1927.
- ¹⁸ McCrea, E. D., McSwiney, B. A., and Stopford, J. B.: Effect on Stomach of Section of Vagi Nerves. Quart. Journ. Exper. Physiol., vol. xvi, p. 195, 1926-1927.
- ¹⁹ Farrell, J.: Physiology of Gastric Secretion. Amer. J. Physiol., vol. lxxxv, p. 685, 1928.
- ²⁰ Hartzell, J. B.: Effect of Vagi Section on Gastric Acidity. Am. J. Physiol., vol. xci, pp. 161-171, 1929.
- ²¹ Lim, R. K. S., Ivy, A. C., and McCarthy, J. E.: Contributions to Physiology of Gastric Secretions. Quart. Journ. Exper. Physiol., vol. xv, pp. 13-55, 1925.
- ²² Heineke: Experimentelle Untersuchungen über die Todesursache bei Perforationsperitonitis. Dtsch. Arch. klin. Med., vol. lxix, 1901.
- ²³ Pigalew and Buschmakina: Experimentelle Befunde zur Frage des Mechanismus direkter Affektionen der Oblongata bei diffuser Peritonitis. Arch. biol. Nauk. (russ). vol. xxviii, H. 3, 1928.
- ²⁴ Manenkow, P. W.: Experimentelle Beiträge zum Mechanismus des direkten Affektion des Oblongata bei akuter diffuser Peritonitis. Zeitschrift für die Gesamte Exp. Medizin, vol. lxvi, H. 3 and 4, pp. 354, 338, 1929.
- ²⁵ Cannon, W. B.: Mechanical Factors of Digestion. London, 1911.
- ²⁶ Koennecke, W.: Experimental Disturbances of Innervation of Stomach and Intestine. Klin. Wchnschr., vol. i, pp. 1262-1263, 1922.
- ²⁷ Latarjet, A.: Resection des nerfs de l'estomie; technique operative; resultats cliniques. Bull. de l'Acad. de méd., vol. lxxxvii, p. 681, 1922.
- ²⁸ Litthauer, M.: Archiv. Klin. Chir., vol. cxiii, p. 712, 1920.
- ²⁹ Nieder: Zentra, für Chir., vol. xlviii, p. 762, 1921.
- ³⁰ Stierlin, E.: Innervation of Stomach in Relation to Etiology and Treatment of Ulcer. Deutsch. Zeitschr. für Chir., vol. clii, p. 358, 1920.
- ³¹ Watanabe: Virchow's Arch., vol. ccli, p. 494, 1924.

RECURRENT PERFORATION OF PEPTIC ULCERS

BY HERMAN E. PEARSE, JR., M.D.

OF ROCHESTER, N. Y.

FROM THE DEPARTMENT OF SURGERY OF THE UNIVERSITY OF ROCHESTER

THE recurrence of an acute perforation of a duodenal ulcer in one of my patients led to the following questions. How frequently does this accident occur? Could any form of treatment have been used at the first operation that would have prevented the second perforation? Standard works on the subject were consulted but failed to give an answer to these questions. A partial review of the literature was made. The reports of 4,813 cases of perforated peptic ulcer were studied. A brief résumé of the data collected is here presented.

CASE REPORT.*—E. N., No. 35,279, a forty-five-year-old white railroad foreman, was admitted to the hospital May 24, 1930, with a complaint of severe upper abdominal pain of fourteen hours' duration.

Present Illness.—For the past fifteen years the patient has had intermittent periods of epigastric distress coming on two hours after meals, associated with gaseous eructation, burning and nausea. This has been relieved by food, soda or enemata. There have been no vomiting or hæmatemesis. Three months before admission he had a bilateral herniotomy done in Cleveland without alteration in digestive symptoms.

Twenty-four hours before admission he was given a barium breakfast for gastrointestinal röntgenograms. He remained in the physician's office the greater part of the day for study. He was told that the X-rays showed "a ptotic dilated stomach with a filling defect typical of ulcer."

At seven that evening he was suddenly seized with a severe epigastric pain which was sharp and tearing in character and did not radiate. The pain was associated with vomiting and prostration. He was brought to the hospital at 9:35 A.M., fourteen and one-half hours after the onset of symptoms.

Physical Examination.—Temperature, 38.2°; pulse, 96; respirations, 34; blood-pressure, 138/100.

The patient was in evident distress. He held himself immobile, had a drawn, anxious expression, was sweating and breathed with shallow rapid respirations. The general physical examination was negative. The abdomen showed retraction below the costal margin with generalized board-like rigidity. There was exquisite tenderness with rebound tenderness over the entire abdomen slightly more marked in the right upper quadrant. Shifting intra-abdominal fluid could not be demonstrated. The liver dullness was not obliterated. Rectal examination showed generalized pelvic tenderness.

Laboratory Findings.—Hæmoglobin, 98 per cent.; red blood-cells, 4,330,000; white blood-cells, 25,400. *Urine.*—Dark yellow. Specific gravity, 1026; sugar, 0; albumin, heavy trace. *Mic.*—Many granular casts with occasional white blood-cells.

Impression.—Perforated peptic ulcer.

Operation.—At 10:35 A.M., fifteen and one-half hours after perforation, under ether anæsthesia, the abdomen was opened through an upper right rectus incision. As soon as the peritoneum was incised, turbid fluid welled out of the wound. A culture was

* This patient was referred to the clinic through the courtesy of Dr. Harold Trott, of Hemlock, New York.

taken. The peritoneum was everywhere reddened and covered with fibrin. There was a perforation one-half inch in diameter on the anterior surface of the duodenum just beyond the pylorus. The opening was closed with through-and-through silk sutures; a second row of inverting mattress sutures was placed above this. Exudate and food particles were carefully aspirated from the abdomen. Because of the long interval between perforation and operation, a drain was placed in the pelvis and brought out through a stab wound in the right lower quadrant. The upper abdominal incision was closed in layers with a small rubber tissue drain to the subcutaneous tissues. The patient stood the operation well and left the table in fair condition.

Post-operative Course.—The patient was given 500 cubic centimetres, 10 per cent. glucose by vein and 2,000 cubic centimetres normal saline by hyperdermoclysis on his return to his room. For the first two post-operative days fluids were supplied by subcutaneous administration. Fluids by mouth were taken on the third day and soft solids on the sixth post-operative day. The rectus incision healed by first intention. The stab wound drained profusely for seven days, then closed and healed. The culture taken at operation showed no growth. The patient's general condition being satisfactory and his wounds well-healed, he was allowed up on his fourteenth post-operative day and was discharged on a modified diet three days later.

Final Diagnosis.—Perforated duodenal ulcer.

Second Admission.—The patient was readmitted October 1, 1931. He stated that he had been perfectly well for more than year after his previous operation. Consequently he had not adhered to the diet prescribed. In July, over two months before admission, he had had a return of epigastric distress with eructations and burning coming on about two hours after meals. He consulted his physician, who prescribed a modified diet and powders. This gave some relief.

On the day of admission at 12:30 P.M. he had a sudden severe epigastric pain just to the right of the mid-line. The pain continued and he entered the hospital four and three-quarter hours after its onset.

Physical Examination.—Temperature, 36.4; pulse, 88; respiration, 26. Blood-pressure, 128/78. The findings were similar to those at his previous admission. A diagnosis of recurrent perforated duodenal ulcer was made and operation advised.

Operation.—Under ether anaesthesia, the abdomen was opened through a paramedian incision. The peritoneal cavity contained many adhesions which when freed allowed escape of a large quantity of food, turbid fluid and gas. The stomach was greatly distended, the pylorus was fibrosed and constricted. Just beyond the pylorus, on the anterior surface of the duodenum, was a perforation one-quarter inch in diameter. This perforation was in exactly the same location as the previous one. The perforation was closed with a double layer of mattress sutures of silk. Since a definite organic pyloric stenosis existed and since the patient's condition was favorable, a posterior gastroenterostomy was done.

The patient had a satisfactory convalescence until his fourteenth post-operative day. At this time he had a right-sided pulmonary infarct. He was just recovering from the effects of this when, six days later, he had a second infarct. Subsequently a bronchopneumonia developed in the right lung. Blood cultures showed no growth. Repeated examinations revealed no evidence of subdiaphragmatic or subhepatic abscess. The temperature remained elevated for sixteen days. At the end of this time it returned to normal. The lung signs cleared. He was allowed out of bed on his forty-third post-operative day and discharged in good condition forty-nine days after operation.

Final Diagnosis.—Recurrent perforation duodenal ulcer; pulmonary infarcts (multiple); bronchopneumonia, right.

Incidence of Recurrent Perforation of Peptic Ulcer.—The reports of 4,813 cases of perforated peptic ulcer were examined and thirty-three instances of recurrent perforation were found. This gives an incidence of

0.69 per cent. of recurrent perforation in perforated ulcer. This figure may be a little low since some authors did not mention recurrent perforation. Instances of it may have occurred which were not recorded.

Can any procedure be used at the time of the first operation which will prevent subsequent perforations?—In its essentials this question is reduced to that of the end-results of surgical management of acute perforated ulcer. For, if ulcers recur after surgical treatment for perforation, then that recurrence renders them liable to re-perforation.

It is desirable, then, to summarize the data related to the results of operative treatment of perforated peptic ulcer. The factors influencing the immediate mortality are:

(1) *Age*.—Very young and very old patients do not withstand the ordeal of perforation as well as do those in the middle groups of life. On the other hand, 71 per cent. of perforations occur between the ages of twenty and fifty years, so that in the majority of patients age is not a conditioning factor.

(2) *The general condition of the patient*.—The presence of cachexia, anæmia, cardiovascular or nephritic lesions or debilitating diseases such as tuberculosis may render the individual incapable of surviving the perforation.

(3) *Character of the lesion*.—The perforation of gastric ulcers results in a higher mortality than does that of duodenal ulcers. Large perforations are more serious than small openings.

(4) *Interval between perforation and operation*.—The elapsed time is the most important of any of the conditioning factors. The mortality has been repeatedly shown to be directly proportional to the interval before operation. The surgeon is powerless to overcome the handicap of a delayed operation. The greatest responsibility rests in the hands of the physicians who first see the patient. The statistics of Dineen well illustrate the importance of early operation.

Ninety-four cases operated upon under six hours, mortality 7 per cent.

Thirty-two cases operated upon between six to twenty-two hours, mortality, 31 per cent.

Sixteen cases operated upon after twenty-two hours, mortality 81 per cent.

The aforestated factors influence the mortality prior to operation. There is nearly universal agreement as to their importance. No such united opinion exists among surgeons as to relative merits of different operative procedures. There is only one positive indication that is agreed upon by all. The opening in the bowel must be closed. When this is not done the mortality is very high. The incomplete procedures which have been attempted include (a) simple drainage; (b) packing or tamponade of perforation with drainage; (c) jejunostomy with drainage; (d) gastrostomy or enterostomy by a tube inserted in the perforation.

These halfway measures fail to meet the one clear-cut indication of operation. They do not close the hole in the bowel.

Aside from the agreement on this principle of closure there is a wide divergence of opinion as to what constitutes the operation of choice for per-

RECURRENT PERFORATION PEPTIC ULCERS

forated peptic ulcer. Each procedure has its advocates. The operations used are: (a) Simple closure of the perforation; (b) excision of the ulcer with closure; (c) excision of the ulcer with pyloroplasty; (d) closure of the perforation with gastroenterostomy; (e) excision of the ulcer with subtotal gastrectomy. For the first two it would seem immaterial whether the ulcer was excised or closed so long as a tight approximation was obtained. The addition of pyloroplasty to the excision would appear on theoretical grounds to be an ideal procedure. It eliminates the perforated ulcer and at the same time creates a more physiological safeguard against recurrence. In our experience it has not fulfilled expectations and has given poor end-results. Hinton has recorded the same observation.

The use of subtotal gastrectomy for the treatment of acute perforated ulcers has been advocated by European surgeons. Granting that gastric resection is often valuable in the treatment of gastric ulcer, it would appear illogical to use it in the presence of a perforation. To do so subjects an already handicapped patient to an extensive major operation. It has not been accepted in this country.

The greatest field of debate has been between the advocates of simple suture and suture plus gastroenterostomy. Guthrie attempted by a questionnaire to find out the consensus of opinion on this topic. One hundred fifty-two answers were received from prominent surgeons throughout the country. Three used pyloroplasty. Of the remainder, twenty-two (14 per cent.) did a gastroenterostomy as a routine, sixty-four (42.1 per cent.) never did a routine gastroenterostomy at the time of perforation, and sixty-three (41.3 per cent.) occasionally added gastroenterostomy to closure of the perforation. It would seem that the correct solution rested with the latter group. In the great majority of instances simple closure of the perforation is sufficient. There are occasional cases where gastroenterostomy is indicated irrespective of the perforation. The statistics reviewed show clearly that the added manipulation of a gastroenterostomy is well tolerated by a robust patient operated upon within twelve hours of perforation. Hence, if there is reason to do the procedure, such as for organic pyloric stenosis, and if the condition of the patient is favorable, there appears to be no contraindication to it. The treatment indicated for the perforation is its closure, that for the pyloric stenosis is gastric drainage with a gastroenterostomy. If the two can, with impunity, be combined at one operation, then it would appear logical to do so. This is entirely different from the proposition that gastroenterostomy should be used routinely in the treatment of perforated ulcers. Such a thesis has little factual basis.

Recurrent Perforation.—These data on acute perforated peptic ulcers give a basis for consideration of their recurrent perforation.

Mortality.—In the group of thirty-three cases of reperforation there were three deaths. The cause of death in one of these cases (Gibson²²) is given as the "result of psychosis." This gives a mortality rate of 9 per cent. However, these thirty-three cases represent a total of seventy-five acute perfora-

tions. Thus the mortality per perforation is 4 per cent. while for perforated ulcers in general it is 27 per cent. Apparently once a patient survives acute perforation of an ulcer he is less apt to die from subsequent perforations. Some factors contributing to this result are:

(1) The presence of adhesions which may limit the extravasated material to localized pockets rather than permitting dissemination through the peritoneal cavity.

(2) The possible increase in the local tissue immunity of the peritoneum from the previous inflammation.

(3) Perhaps most important is the fact that the patient has had this experience before, he makes his own diagnosis, and presents himself for treatment early.

The Influence of Previous Surgical Treatment on the Incidence of Reperforation.—Recurrent perforation of an ulcer is merely one manifestation of recurrent ulceration. As such its incidence should correlate with that of recurrent ulcer after surgical treatment of a perforation. However, in the cases studied there were no instances of reperforation following the use of pyloroplasty or subtotal gastrectomy. These procedures were used in only about 6 per cent. of cases, so this fact is interpreted to lack of data rather than to the prophylactic properties of these operations. Both, when used for non-perforating ulcer, lead to instances of recurrent ulceration. If they should be used extensively for treating the acute perforation of ulcers, then occasional cases of recurrent ulceration would be expected and these in turn would be liable to reperforation.

Johnson found that in 1,056 cases of perforated ulcer, 710 (67.2 per cent.) were treated by suture, 281 (26.6 per cent.) by suture and gastroenterostomy and sixty-five (6.2 per cent.) by all other methods. In the thirty-three cases of reperforation, twenty-four (72.7 per cent.) were treated by suture, eight (24.3 per cent.) had an added gastroenterostomy, and in one (3 per cent.) the method was not stated. It is seen that the percentage of reperforation after these surgical procedures approximates the respective incidence of their use.

There is one additional fact worthy of note. In only one of the twenty-four cases of reperforation after suture was there a total of more than two perforations. This one case had three acute perforations. In the eight cases following an original suture and gastroenterostomy there were five cases who reperforated three or more times. In three of these a jejunal ulcer was responsible. It is ironical to note that one of the cases was originally operated upon by Deaver,¹² formerly the foremost advocate of routine gastroenterostomy in the treatment of acute perforated ulcers. Following his original operation, this patient survived two subsequent perforations that were treated by suture. It would seem, therefore, that the recurrent perforations after gastroenterostomy are more apt to be multiple and hence of more serious consequence. Two of the three deaths in the series occurred among the eight patients who had had a primary gastroenterostomy.

RECURRENT PERFORATION PEPTIC ULCERS

SUMMARY

(1) A case of recurrent perforation of a duodenal ulcer is recorded.

(2) The reports of 4,183 cases of perforated peptic ulcer were examined and thirty-three instances of reperforation were found. This gives an incidence of 0.69 per cent., or an average of one case in 145 cases of acute perforated ulcer.

(3) In the group of thirty-three recurrent perforations, there were three deaths, a mortality of 9 per cent. The group represents a total of seventy-five acute perforations, so that the mortality per perforation is 4 per cent. This is much lower than that for acute perforated ulcers in general, which have an average mortality rate of 27 per cent.

(4) In the thirty-three cases of reperforation, twenty-four (72.7 per cent.) were originally treated by simple closure, eight (24.3 per cent.) had an added gastroenterostomy, and in one (3 per cent.) the method was not stated. This correlates with the statistics for the management of acute perforated peptic ulcers which shows 67.2 per cent. treated by simple closure, 26.6 per cent. by closure and gastroenterostomy and 6.2 per cent. by all other methods.

(5) Only one of the twenty-four cases of reperforation treated by suture had more than two acute perforations. Of the eight patients who had a primary gastroenterostomy, five perforated three or more times. A jejunal ulcer was responsible in three of these cases. Two of the three deaths in the series of reperforation occurred in this group which had had a primary gastroenterostomy.

BIBLIOGRAPHY

- ¹ Balfour, D. C.: Results of Gastroenterostomy for Ulcer of the Duodenum and Stomach. *ANNALS OF SURGERY*, vol. xcii, p. 558, 1930.
- ² Ball, W. G.: Perforated Gastric and Duodenal Ulcers. *St. Bart. Hosp. Rep.*, vol. lix, p. 49, 1926.
- ³ Brenner, E. C.: Perforated Ulcers of the Duodenum. *ANNALS OF SURGERY*, vol. lxxxvi, p. 393, 1927.
- ⁴ Brown, H. P.: Perforation of Peptic Ulcer. *ANNALS OF SURGERY*, vol. lxxxix, p. 209, 1929.
- ⁵ Brown, K. P.: The Late Results in a Series of Forty-nine Cases of Perforated Gastric and Duodenal Ulcers. *Edinburgh Med. Jour.*, vol. xxxii, p. 207, 1925.
- ⁶ Caird, F. M.: Perforated Duodenal Ulcer. *Edinburgh Med. Jour.*, vol. xi, p. 405, 1913.
- ⁷ Cellan-Jones, C. T.: A Rapid Method of Treatment in Perforated Duodenal Ulcer. *Brit. Med. Jour.*, vol. i, p. 1076, 1929.
- ⁸ Colp, R.: Perforated Gastroduodenal Ulcers. *N. Y. State Jour. Med.*, vol. xxix, p. 13, 1929.
- ⁹ Cope, Z.: Treatment of Perforated Gastric and Duodenal Ulcers. *Brit. Med. Jour.*, vol. i, p. 139, 1925.
- ¹⁰ Cutler, E. C., and Newton, F. C.: Perforated Ulcer of the Stomach and Duodenum. *Boston Med. and Surg. Jour.*, vol. clxxxviii, p. 789, 1923.
- ¹¹ *Davenport, G. L.: Five Operations in Twelve Years for Perforation. *Jour. Am. Med. Assn.*, vol. xcvii, p. 99, 1931.
- ¹² Deaver, J. B., and Pfeiffer, D. B.: Gastroenterostomy in Acute Perforated Ulcer of the Stomach and Duodenum. *ANNALS OF SURGERY*, vol. lxxiii, p. 441, 1921.

- ¹³ *Dineen, P.: Acute Perforated Ulcers of the Stomach and Duodenum. *ANNALS OF SURGERY*, vol. xc, p. 1027, 1929.
- ¹⁴ Dunbar, J.: Acute Perforated Peptic Ulcer. *Glasgow Med. Jour.*, vol. cvi, p. 109, 1926.
- ¹⁵ *Eliot, E.: The Clinical Features and Treatment of Acute Perforated Gastric and Duodenal Ulcers. *ANNALS OF SURGERY*, vol. lv, p. 546, 1912.
- ¹⁶ Evans, A. J.: Operative Treatment of Acute Perforated Ulcer of the Stomach and Duodenum. *Brit. Med. Jour.*, vol. i, p. 184, 1926.
- ¹⁷ *Farr, C. E.: Perforated Gastric and Duodenal Ulcer. *ANNALS OF SURGERY*, vol. lxxii, p. 591, 1920.
- ¹⁸ Finney, J. M. T., and Hanrahan, E. M.: Results of Operations for Chronic Gastric and Duodenal Ulceration. *ANNALS OF SURGERY*, vol. xcii, p. 620, 1930.
- ¹⁹ Fleming, B. L.: Acute Perforation of Duodenal Ulcers. *Jour. Am. Med. Assn.*, vol. xcvi, p. 6, 1931.
- ²⁰ Gatewood: The Immediate Mortality and Late Results of Operation for Peptic Ulcer. *ANNALS OF SURGERY*, vol. xcii, p. 554, 1930.
- ²¹ Gibbon, J. H.: The Immediate Mortality in Operations for Gastric and Duodenal Ulcer and Its Causes. *ANNALS OF SURGERY*, vol. xcii, p. 616, 1930.
- ²² *Gibson, C. L.: Acute Perforations of the Stomach and Duodenum. *Boston Med. Surg. Jour.*, vol. clxxix, p. 425, 1923. *Ibid.*: *Jour. Am. Med. Assn.*, vol. xci, p. 1006, 1928.
- ²³ Guthrie, D.: Should Gastroenterostomy Be Performed in the Presence of Ruptured Duodenal Ulcer? *N. Y. State Jour. Med.*, vol. xxiii, p. 66, 1923.
- ²⁴ *Henry, C. K. P.: Recurrent Gastric Perforations. *Surg., Gynec., and Obst.*, vol. xxxii, p. 542, 1921.
- ²⁵ Hinton, J. W.: The Horsley Pyloroplasty in Acute Perforated Duodenal Ulcers. *Surg., Gynec., and Obst.*, vol. xlvii, p. 407, 1928.
- ²⁶ *Hinton, J. W.: Acute Perforated Ulcers of the Stomach and Duodenum. *Surg., Gynec., and Obst.*, vol. lii, p. 778, 1931.
- ²⁷ *Johnson, L. B.: Acute Perforation of Gastric and Duodenal Ulcers. *Internat. Clinics*, vol. ii, p. 145, 1926.
- ²⁸ *Lewisohn, R.: Persistence of Pyloric and Duodenal Ulcers Following Simple Suture of an Acute Perforation. *ANNALS OF SURGERY*, vol. lxxii, p. 595, 1920.
- ²⁹ Lewisohn, R.: Late Results in Perforated Gastroduodenal Ulcers. *ANNALS OF SURGERY*, vol. lxxxvii, p. 855, 1928.
- ³⁰ *McCreery, J. A.: Acute Perforated Ulcer of the Stomach and Duodenum. *ANNALS OF SURGERY*, vol. lxxix, p. 91, 1924.
- ³¹ *McKnight, H. A.: Recurring Perforation of Stomach and Duodenum. *ANNALS OF SURGERY*, vol. lxxvii, p. 108, 1923.
- ³² *McQuillan: Recurrent Ruptured Gastric Ulcer. *ANNALS OF SURGERY*, vol. xlv, p. 302, 1931.
- ³³ Meyer, K. A., and Brams, W. A.: Acute Perforation of Gastric and Duodenal Ulcer. *Am. Jour. Med. Sci.*, vol. clxxi, p. 510, 1926.
- ³⁴ Mills, G. P.: The Treatment of Perforated Gastric and Duodenal Ulcers. *Brit. Med. Jour.*, vol. i, p. 12, 1925.
- ³⁵ Moynihan, B.: Perforation of Gastric and Duodenal Ulcer. *Practitioner*, vol. cxx, p. 137, 1928.
- ³⁶ Noehren, A. H.: Acute Perforation of Gastric and Duodenal Ulcers. *Am. Jour. Surg.*, vol. xxxviii, p. 59, 1924.
- ³⁷ Odelberg, A.: Primary Resection of the Stomach in Perforated Gastric and Duodenal Ulcers. *Acta. Chir. Scand.*, vol. lxii, p. 159, 1927.
- ³⁸ *Pannett, C. A.: The Surgery of Gastroduodenal Ulceration. Oxford Univ. Press, 1926.
- ³⁹ Pool, E. D., and Dineen, P. A.: Late Results of Gastroenterostomy for Gastric and Duodenal Ulcers. *ANNALS OF SURGERY*, vol. lxxvi, p. 457, 1922.

RECURRENT PERFORATION PEPTIC ULCERS

- ⁴⁰ Radoievitch, S.: Du Meilleur traitement chirurgical des ulcers gastroduodenaux perfores en peritoine libre. *Rev. de Chir.*, vol. lxiii, p. 161, 1925.
- ⁴¹ *Richardson, E. P.: Acute and Subacute Perforation of the Stomach and Duodenum at the Massachusetts General Hospital. *Boston Med. Surg. Jour.*, vol. clxxvi, p. 158, 1917.
- ⁴² Smith, F. K.: Diagnosis and Treatment of Perforated Duodenal Ulcer. *Brit. Med. Jour.*, vol. ii, p. 1068, 1921.
- ⁴³ Southam, A. H.: The Treatment of Perforated Gastric and Duodenal Ulcer. *Brit. Med. Jour.*, vol. i, p. 556, 1922.
- ⁴⁴ Stenbuck, J. B.: Causes of Death Following Operations for Perforated Gastric and Duodenal Ulcers. *ANNALS OF SURGERY*, vol. lxxxv, p. 713, 1927.
- ⁴⁵ *Turner, G. G.: The Perforations of Gastric and Duodenal Ulcers. *Lancet*, vol. i, p. 183, 1925.
- ⁴⁶ Urrutia, Louis: Late Results in Perforated Gastroduodenal Ulcers. *ANNALS OF SURGERY*, vol. xc, p. 73, 1929.
- ⁴⁷ White, W. C., and Patterson, H. A.: Late Results of Simple Suture in Acute Perforations of Duodenal Ulcer. *ANNALS OF SURGERY*, vol. xciv, p. 242, 1931.
- ⁴⁸ *Williams, H., and Walsh, C. H.: Treatment of Perforated Peptic Ulcer. *Lancet*, vol. i, p. 9, 1930.
- ⁴⁹ Winslow, N.: Perforating Gastric and Duodenal Ulcer. *ANNALS OF SURGERY*, vol. lxxiv, p. 721, 1921.

* These authors report cases of recurrent perforation.

RESECTION OF THE FUNDUS OF THE STOMACH FOR PEPTIC ULCER

BY F. GREGORY CONNELL, M.D.

OF OSHKOSH, WISCONSIN

THE evolution of the surgical treatment of peptic ulcer shows a gradual development from gastrojejunostomy, pyloroplastics, local excision or destruction, duodenal resection, pylorotomy and partial gastrectomy to subtotal gastrectomy.

Because of the unsatisfactory results, removal of the "ulcer-bearing area" has been gradually enlarged upon, extended toward the cardia with removal of more and more of the fundus.

Because of repeated recurrences after extensive removal of the fundus it has been recommended that the gastro-intestinal continuity be reestablished by gastro- (or fundo) duodenostomy, instead of the usual gastro-jejunal anastomosis. This union of the fundus and the duodenum seems to be looked upon as the important factor, while another, possibly the more important factor, *i.e.*, removal of additional acid-secreting mucous membrane—in effect a partial fundusectomy—has not been emphasized.

A new principle has been suggested in which the ulcer is allowed to remain and an attempt is made to counteract, or remove, a supposed cause—the hydrochloric acid—by removal of the fundus. This allows retention of the normal antro-pyloro-duodeno neuromuscular mechanism, instead of the formation of an artificial, unnatural and incompetent fundo-duodeno reunion.

With removal of equal amounts of acid-secreting fundus, and in one case sacrifice of, and in another retention of, this normal acid base regulatory structure at the pylorus, it seems reasonable to expect more favorable results in the latter.

If removal of the fundus—the acid-secreting portion of the gastric wall—is to be carried out, it seems logical to do so as a first, rather than a late step, thereby possibly eliminating one or more unnecessary operative procedures.

Fundusectomy fulfills satisfactorily the three requirements of the surgical treatment of early duodenal ulcer as outlined by Balfour,¹ *viz.*, insignificant risk, with good prospect of permanent cure, and does not interfere with future surgical treatment, if ulcer develops subsequently.

Theoretically,² experimentally³ and clinically such a procedure is practicable in selected cases of either primary or secondary ulcer.

The report of a clinical case follows:

CASE I.—H. P., referred by Dr. T. D. Smith, of Neenah, Wisconsin. Aged twenty-four years, male, married, mill worker by occupation. Father died of carcinoma of

FUNDUSECTOMY FOR PEPTIC ULCER

the stomach. Mother: Living, has "gall-stones." Sister: One, gastroenterostomy for "ulcer of stomach." Brother: One, gastroenterostomy for "perforation of ulcer of the stomach"; one has "ulcer of stomach."

Past History.—"Rheumatism" ever since a child. During 1916 and 1917, was invalided for about one year. In 1926, a severe attack of acute rheumatism, which was followed by a tonsillectomy.

Present History.—Sudden onset of "indigestion" in March, 1928, characterized by gas, epigastric discomfort, nausea, belching, rarely regurgitation and still more rarely vomiting, occurring a few hours after eating and at night. Relieved by food or soda. Occasionally, there is a rather severe cramp-like pain, definitely localized in epigastrium or right hypochondrium which does not radiate. The above complaint is constant and similar every day. Constipation is of long standing, there is no qualitative food distress. Appetite is good, with no weight loss and no jaundice. Patient continued at work on a milk diet and soda with continuation of symptoms. In May, 1928, at 10 A.M., while at work, he experienced severe abdominal pain with collapse. He was taken to Theda Clark Memorial Hospital where a diagnosis of acute perforation of gastric ulcer was followed by closure of the perforation and a gastrojejunostomy. Recovery was prompt and satisfactory.

The patient remained symptom-free until July, 1929, when dietary indiscretion was followed by a return of gastric symptoms, distress and discomfort, no pain, with characteristic food ease, for which he was again placed upon a "diet and soda" and continued at his work.

In August, 1929, sudden nausea, distress, gas, weakness, syncope, pallor, palpitation, vomiting of blood and melena. There was no abdominal pain. The patient was placed in the hospital for treatment. The laboratory findings revealed: Blood, hæmoglobin, 53 per cent.; red blood-cells, 3,570,000; white blood-cells, 13,600. Urine, albumin and casts. Pulse, 150. Blood-pressure, 90/60.

A few days later there was high temperature with acute pains in arms, legs, hips and neck, with an acute endocarditis. The treatment consisted of "salicylates and alkalis" with milk and cream diet. This was followed by prompt relief of arthritic and cardiac symptoms and he soon left the hospital, but with continued gastric distress.

In September, 1929, X-ray examination was made which demonstrated that the stoma of the gastroenterostomy was patent and that the duodenum was not normally visualized.

Distress one and one-half to two hours after eating, with relief by food or soda; symptoms exactly the same as before operation, continued through October.

In November, 1929, abdominal tenderness at umbilicus was complained of; melena, but no vomiting, with secondary anæmia continued. The gastric symptoms with gradually increasing weakness in December, 1929, forced re-hospitalization. A second laparotomy was performed January 6, 1930. The old ulcer was found to have healed, with no crater, induration, stippling or obstruction at the duodenum; but at the stoma there was a pea-sized induration with stippling of the serosa. This ulcer was excised, the gastroenterostomy "taken down" and the openings in the stomach and the jejunum were closed.

February 6, 1930, the patient was discharged from the hospital upon a diet with no gastric complaint. He remained fairly comfortable with occasional days in which there was complaint of gas, distress and fullness, usually after dietary indiscretion. Such spells occurred with increasing frequency until in August, 1931, his symptoms were practically the same as before the first operation; distress and food ease with increasing pain in upper right abdomen and in epigastrium, with weight loss, from 180 pounds to 155 pounds, high gastric acidity, with no hematemesis or melena. In September, 1931, X-ray examination revealed pylorus deformed, but functioning, with no ten-hour retention.

Symptoms continued despite rest and medical management. December 14, 1931, operation for recurrent duodenal ulcer, a third laparotomy with fundusectomy, was carried out.

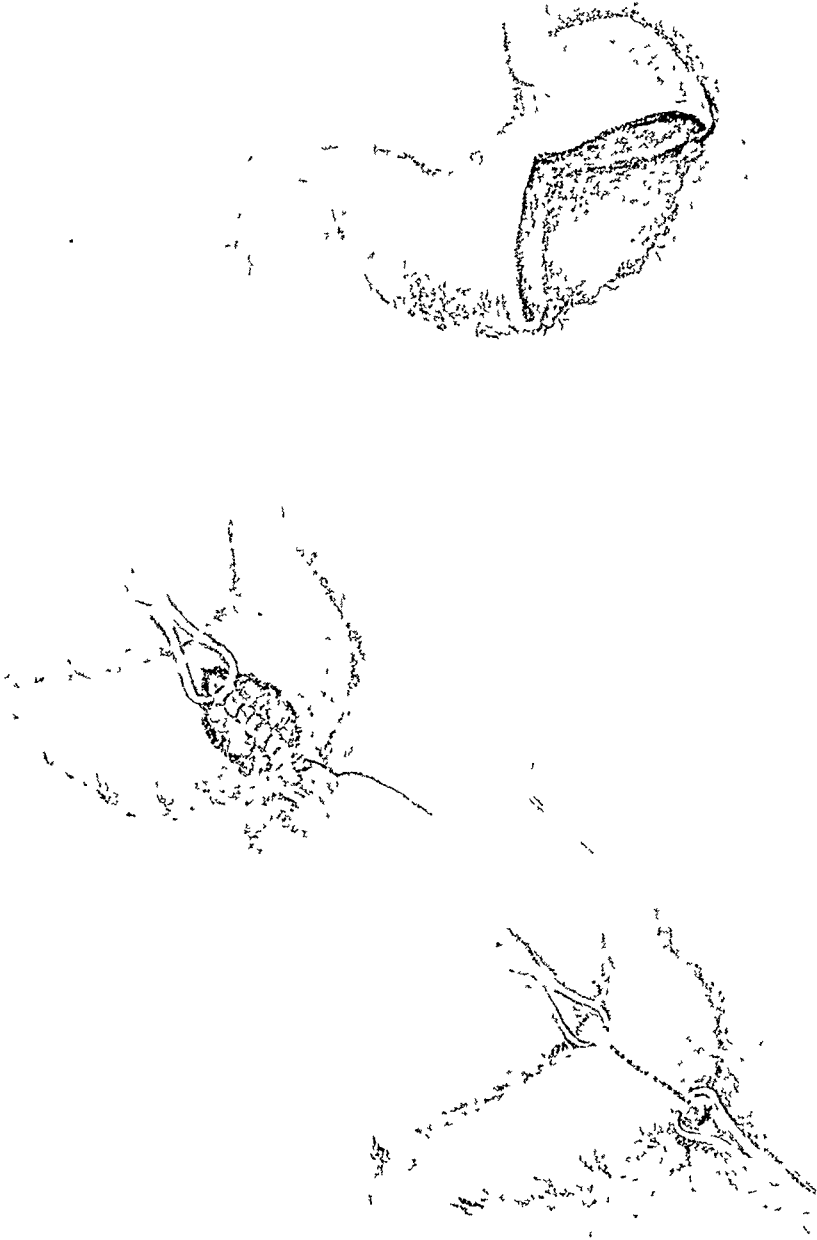


FIG. 1.—Resection fundus of stomach in treatment of peptic ulcer.

The immediate post-operative result was entirely satisfactory. The man left the hospital on the twenty-first day and, to date, has been symptom-free, but the well-known irregularities and remissions in the natural course of peptic ulcer necessitate considera-

tion of many cases and the elapse of ample time before results may be intelligently discussed or properly evaluated.

The technic of fundusectomy is simple. After opening the abdomen, careful exploration of the abdominal viscera allows confirmation of the previous diagnosis of a patent pylorus. Delivery of the stomach (and stoma in cases in which the jejunum is still attached) is followed by division of the greater omentum between doubly ligated vessels, for the distance that the greater curvature is to be removed—about the middle half—after which the peritoneal cavities may be carefully “walled off.”

From the chosen points, on the greater curvature, the anterior and posterior walls are divided—the incisions extending obliquely upward and meeting about one inch below the lesser curvature—in this way removing a triangular fragment of stomach fundus, with approximately half of the greater curvature as its base, with anterior and posterior walls meeting at a point just below the lesser curvature, which is retained intact. (Fig. 1.)

By grasping, with forceps, the posterior wall at the upper limit of the incision, and the greater curvature at each line of incision, the divided posterior stomach wall will be held in suitable apposition and position for hemostasis and suture.

The reconstruction is made with one, or two, layers of chromic catgut; beginning at the upper extremity on the mucous surface and extending to the greater curvature. The upper extremity of the united posterior wall is then released and the upper extremity of the as yet ununited anterior wall is grasped by forceps, which, with the forceps remaining at the greater curvature, hold the anterior wall in suitable position for over-and-over continuation of the suture (before completing the closure the gastric, pyloric or duodenal lumen may be carefully examined). The omentum is now attached to the reconstructed greater curvature and the abdomen closed without drainage.

BIBLIOGRAPHY

- ¹ Balfour, D. C.: *Trans. West. Surg. Assn.*, 1931; *Jour. Am. Med. Assn.*, February 13, 1932.
- ² Connell, F. Gregory: *Surg. Gynec., and Obst.*, vol. xlil, No. 5, p. 696, November, 1929.
- ³ Connell, F. Gregory: *Surg., Gynec., and Obst.*, vol. liii, No. 6, p. 750, December, 1931.

PEPTIC ULCER IN INFANTS UNDER ONE YEAR OF AGE

By JEROME SELINGER, M.D.

OF NEW YORK, N. Y.

FROM THE PEPTIC ULCER CLINIC OF THE NEW YORK POST-GRADUATE HOSPITAL

GASTRIC and duodenal ulcers in infants under one year of age are not so rare as they were formerly supposed to be. The former condition is less frequently encountered than the latter, but the literature is by no means scanty in case reports of both.

Reading the literature for the purpose of gathering data on gastric and duodenal ulcer in infants under one year of age leaves much to be desired. The information regarding age, sex, and diet of infants dying of ulcer is very meagre. Moynihan, for example, Second Edition, 1912, gives sixteen case reports of various authors. Of these, four were female, two male, and in ten the sex was not stated. Many reports giving the case history and autopsy findings will state that the patient was a child, and leave one totally in the dark as to whether the child was a year or six years of age. Very few reports give any indication regarding the diet, and one cannot know whether the infant in question nursed or was fed a formula.

One must exercise care not to confuse true ulceration in infants with superficial necrosis or intestinal decomposition. These latter conditions are prone to occur very soon after death. Unless the area suspected has a definite punched-out appearance with sharp edges, one should hesitate to include the case with those of true ulceration.

The first recorded case is that reported in 1825 by Siebold.¹ It was a perforation of a gastric ulcer in an infant two days old. Hecker and Buhl,² in 1864, reported the first case of duodenal ulcer. Spiegelberg³ reports death from perforation of duodenal ulcers in two infants five and twenty-four hours old, respectively.

Since then the literature is sprinkled with numerous reports of ulcers discovered accidentally in doing a routine autopsy following death due to other causes; or from death due to hæmorrhage or perforation of an ulcer. Rarely is the condition diagnosed previous to operation or death.

Holt⁴ states that in 1800 post-mortem examinations made at The Babies Hospital, 90 per cent. in children under one year of age, ulcer was found only four times—.222 per cent. He does not specify whether these are gastric or duodenal. Compared with most other reports, this is a very low percentage. Schmidt,⁵ for example, in his exhaustive monograph, reports ulcer in 1.8 per cent. of cases in 1,109 autopsies performed on children under one year of age. This is eight times the percentage reported by Holt. Both articles were published the same year.

Schmidt makes the further statement, and quotes figures to prove it, that duodenal ulcer is more frequently encountered during the first year of life than at any other time. This is certainly contrary to the general belief.

Sturtevant and Shapiro,⁶ reporting results on 7,700 autopsies at Bellevue Hospital, found gastric ulcer in five children under one year of age. This is of little statistical value for the autopsies were on individuals of all ages.

PEPTIC ULCER IN INFANTS

Veeder⁷ reports having seen five cases of duodenal ulcer in infants under one year of age. These were at the St. Louis Children's Hospital. He calls attention to the fact that this condition, when it does occur, is most frequent in the first four months of life.

Butka⁸ says: "Although the literature abounds in reports of duodenal ulcer, the occurrence of gastric ulcer in infants is exceedingly rare. Careful search has revealed only three cases of ruptured gastric ulcer in infants under two months of age." This may be an accurate statement in so far as American authors are concerned. As will be shown later in this paper, there are many such cases on record.

Helmholz,⁹ in 1909, reported nine cases of duodenal ulcer in infants under four months and an additional report of seven cases seven months or under. Four of the latter group had two or more ulcers.

Multiple ulceration either in the stomach or duodenum is not infrequently reported. These may be of the kissing variety, or sufficiently removed from each other and so placed that contact could play no part in their occurrence. As many as five separate and distinct ulcers have been found in the same infant.

Numerous other authors, including Thoms,¹⁰ Kobes,¹¹ Palmer,¹² Billard,¹³ Schwab and Le Bourlier,¹⁴ Somerford,¹⁵ and Stern, Perkins and Nessa,¹⁶ report numerous cases of both gastric and duodenal ulceration.

Rogers¹⁷ reports two cases of duodenal ulceration in the same family—one appearing at seven weeks, and the other at two months. The first case had three separate and distinct ulcers.

Nixon and Fraser¹⁸ report several cases of ulceration at the cardiac end of the stomach. In one case the ulceration completely surrounded the œsophagus. This must be an unusually rare condition, as I find no further reference to it in the literature.

The classic monograph of Theile¹⁹ includes ulceration in children up to sixteen years of age. Extracting those cases that fall within the age limit of this paper, we find case reports on 137 ulcers. Of these there were: gastric, 51; duodenal, 78; location not stated, 5; multiple, 3. His figures show that the greatest number occur during the first few days of life and that perforation is more frequent in gastric than in duodenal cases.

It seems fair to assume that many cases of melena neonatorum have an ulcer basis. Some of these patients recover and a diagnosis is never made. Others die and no autopsy is performed. One has no way to determine the number of ulcers that pass undiagnosed.

In the stomach these ulcers are generally, though not necessarily, situated on or near the lesser curvature. In the duodenum they are practically always on the posterior wall, nearer the papilla than the pylorus.

I shall here add three unreported cases of gastric ulcer:

CASE I.—Patient of Dr. Adolph G. De Sanctis. Female, aged two months, eleven days. Discharged April 12, 1931, for respiratory infection. Re-admitted April 20, 1931, bilateral swelling ear drums. Operation April 20, 1931, bilateral myringotomy. Blood transfusion. Died April 21, 1931, at 5.45 A.M. Autopsy at 9.30 A.M. Inspissation pneumonia; double otitis media. Gastro-intestinal tract—stomach: at the lesser curvature near the pyloric sphincter there were two areas of necrosis surrounded by a zone of marked congestion, each measuring about thirty millimetres in diameter. The two areas merged into one another, and on further dissection revealed two areas of perforation most probably due to handling of this necrotic tissue. The rest of the gastro-intestinal tract was negative. Pancreas negative. Sections of the stomach wall taken around the ulcer revealed marked œdema and extensive polymorphonuclear cell and eosinophilic infiltration of the entire thickness of the wall. There was a large amount of purulent exudation on its outer surface. The mucosa of the stomach wall was gangrenous and exfoliated over the ulcerated area. The tissue beyond the ulcer was

congested and œdematous. The entire ulcerated area and the injected area around the periphery of the ulcer was also extensively infiltrated by a fungus made up of branching filaments and quite a large number of spores. Further discussion with the pathologist revealed the fact that sprue was probably the basis of the ulcers. Microscopical examination.—*Diagnosis*—inspissation pneumonia; acute gangrenous ulcers of stomach, showing the presence of a large number of segmented, branching, spore-bearing filaments; encephalitis. *Final Diagnosis*.—Bronchopneumonia; acute double otitis media; acute ulcers of stomach.

CASE II.—Patient of Dr. Harold Denman Meeker. Male, aged three months. History.—In spite of every effort, patient vomited persistently for about three weeks prior to operation. There had been great difficulty in feeding him since birth. At operation an ulcer about a centimetre and a half from the pyloric sphincter was found on the anterior surface close to the greater curvature. There had been a perforation, but the opening had been walled off by adherent omentum. A simple closing of the ulcer margins was done, using fine chromic gut, reinforcing the surface by stitching omentum over the peritoneum and then doing a posterior gastrojejunostomy, the surgeon feeling at the time that this operation could be done more rapidly and with less shock than a pyloric operation. Patient made an excellent recovery.

CASE III.—Patient of Dr. Marshall C. Pease. Male, eleven months old. History.—Vomited feedings for several days; this was followed by vomiting of blood; melena; rapid collapse, and death. Autopsy performed within one hour after death showed a perforated ulcer on the anterior surface of the stomach close to the lesser curvature.

With such facts before us, it seems fair to assume that duodenal ulcer in infants under one year of age is certainly not a rarity. Furthermore, with new cases of gastric ulcer constantly being reported, it is reasonable to conclude that this condition occurs much more frequently than is generally supposed.

Like peptic ulcer in the adult, it is, in infants, probably due to a combination of conditions. Anything that lowers general resistance certainly predisposes to whatever the active agent may be. Holt⁴ says: "In sixty-five cases in which the age is given, 70 per cent. occur between the sixth week and the fifth month. This corresponds closely with the age incidence in death from marasmus." Theile¹⁹ stresses the point that a majority of the cases reported by him had one of the numerous constitutional diseases such as marasmus, tuberculosis, syphilis, uræmia, *etc.* Helmholz²⁰ says: "They have some connection with antecedent wasting illness, for such enfeebled infants more rapidly develop ulcer." Moynihan²¹ says: "In poorly nourished, atrophic infants, ulcer is probably very frequently present."

Thus the normally delicate structures of the infant, having been further enfeebled by some wasting disease, fall an easy prey to a variety of infectious organisms. The work of Saunders,²² while it does not refer to ulcers in infants, is applicable and most illuminating. Rosenow,²³ as well as Gerdine and Helmholz,²⁴ report clinical and experimental evidence supporting the infectious nature of ulcer. More recently, Kennedy²⁵ has isolated a streptococcus from ulcer. He also finds streptococci and other bacteria in the ulcer tissue but none in the tissues surrounding the ulcer.

Most of the authors quoted herein, particularly Schmidt,⁵ emphasize local thrombosis as a frequent cause. There is no doubt that the thrombus will

cause ulceration, but we must go one step beyond this and relate the cause of the thrombosis.

Traumatism, either in normal or difficult delivery, must be considered as an important factor in the causation of ulcer. Such injury would certainly reduce the resistance of a normal or already enfeebled membrane. It would be prone to slow up the circulation or cause ecchymosis or even thrombosis. The tissues are then an easy prey to bacterial attack. If the condition can take place in tissue hardened to resist trauma, it must certainly occur frequently in the sensitive internal membrane of the enfeebled infant.

The fact that all such ulcers show a complete absence of round-cell infiltration and all other evidence of inflammatory reaction, in other words, that there is only evidence of destruction, none of repair, is no argument against the bacterial theory. There must be present at least normal resistance to stimulate round-cell infiltration and the other reactions to bacterial invasion. These factors are not present in the type of infant most likely to be affected with ulcer.

Unfortunately, the condition is practically never suspected or diagnosed until hæmorrhage or perforation occurs. It is then practically always too late to help. One of the three cases reported in this paper was diagnosed previous to operation by Doctor Meeker, and the result was a happy one. This is the youngest case reported of a successful operation for a perforated gastric ulcer.

Until blood appears, most often in the stool but not infrequently in the vomitus, there is practically no definite sign or symptom upon which an accurate diagnosis can be made. Abt's "Pediatrics," p. 535, quoting Holt, says: "Perforation and hæmorrhage are exceedingly rare." I think the numerous reports herein will successfully refute such a statement. Vomiting or the spitting up of sour fluid is so frequent that one would certainly not suspect ulcer unless there were other more damaging evidence. Realizing, however, that ulceration is frequently found in infants, persistent vomiting should make one suspicious that he may be dealing with an organic lesion. Occasionally symptoms of pyloric obstruction are noted in connection with some hæmorrhage. This should give a clue to the diagnosis, and has been elaborated upon by Finny²⁶ and Helmholtz,⁹ quoting Birk. When, after persistent vomiting with or without blood, plus active melena, there is a sudden collapse, one can be assured that the underlying condition is in all probability peptic ulcer. Even at autopsy the condition is likely to be overlooked, for the ulcer may be very small and obscured by blood or fibrin.

If ulcer is suspected, one can safely resort to the X-ray, which should certainly be regarded as being the best ally in making a diagnosis. I find only two references to the utilization of this method—Stern, Perkins and Nessa,¹⁶ and C. Pedrazzi.²⁷ The first-mentioned authors give a complete case history of a two-day old infant. By means of a catheter, sufficient barium was instilled into the stomach to permit hourly X-ray exposures. The report showed a niche on the lesser curvature near the pylorus.

Little is reported in the matter of treatment. Apparently little need be said. Surgery certainly holds the only hope of a cure. Even with surgery the outlook is none too brilliant. Unless the diagnosis has been made early and surgery resorted to before perforation or massive hæmorrhage has taken place, the prognosis is indeed gloomy. The case reported in this paper operated upon by Doctor Meeker is certainly the exception that, one might say, proves the rule. Repair of the perforation or suturing the ulcer, with arrest of the hæmorrhage done as quickly as possible, offers the best hope for a live patient. In older children, according to Henderson,²⁸ medical treatment is the method of choice.

SUMMARY

(1) Duodenal and gastric ulcer—particularly gastric—in infants under one year of age occur much more frequently than is generally supposed, at least in 1.8 per cent. of cases. With more autopsies and a closer inspection of the viscera involved, this percentage would undoubtedly be greatly increased.

(2) They practically always occur in infants who have some constitutional disease—particularly marasmus. Traumatism and infection are perhaps secondary causes.

(3) Except in rare cases, the diagnosis is never made until perforation or persistent and massive hæmorrhage occurs.

(4) The treatment is early surgical interference.

BIBLIOGRAPHY

- ¹ Siebold: *Journ. f. Geburtshilfe*, vol. v, Heft 1, 1825.
- ² Hecker, and Buhl: *Klinik der Geburtskunie*, vol. ii, Leipzig, 1864.
- ³ Spiegelberg: *Jahrb. f. Kinderh.*, 3 Folge, Bd. 11, 1868-1869.
- ⁴ Holt, L. Emmett: *Am. Jour. Dis. of Child.*, vol. vi, p. 381, December, 1913.
- ⁵ Schmidt, W.: *Das Ulcus Rotundum im. 1 Lebensjahr*. *Berl. klin. Wchnschr.*, S. 593, 1913.
- ⁶ Sturtevant, Mills, and Shapiro, Louis L.: *Gastric and Duodenal Ulcer*. *Arch. Int. Med.*, vol. xxxviii, p. 41, July, 1926.
- ⁷ Veeder, Borden S.: *Duodenal Ulcer in Infancy*. *Am. Jour. Med. Sc.*, vol. cxlviii, p. 709, 1914.
- ⁸ Butka, H. E.: *Ruptured Gastric Ulcer in Infancy*. *Jour. Am. Med. Assn.*, vol. lxxxix, p. 198, July 16, 1927.
- ⁹ Helmholz, H. F.: *Duodenal Ulcer in Infancy*. *Arch. Pediat.*, vol. xxvi, p. 661, 1909; *Duodenal Geschwure und Pedatrophie*. *Deutsch. Med. Wchnschr.*, p. 534, 1909.
- ¹⁰ Thoms, Amy M.: *Case of Duodenal Ulcer in an Infant*. *Lancet*, vol. ii, pp. 854-855, October 25, 1924.
- ¹¹ Kobes, Rudolf: *Zentralbl. f. Gynak.* No. 11-A vol. lv, pp. 995-999, March 14, 1931.
- ¹² Palmer, Arthur: *Autopsy Report*. *Med. Jour. Australia*, vol. i, pp. 467-468, April 14, 1928.
- ¹³ Billard: *Traite des Maladies des Enfants*. S. 296. Paris, 1828.
- ¹⁴ Schwab, and Le Bourlier: *Bulletin of the Society of Obstetrics and Gynecology*, December, 1928.
- ¹⁵ Somerford, A. E.: *Perforation of Duodenal Ulcer in Child Fourteen Days Old*. *Lancet*, vol. i, p. 1015, May 10, 1930.

- ¹⁰ Stern, M. A., Perkins, E. L., and Nessa, N. J.: Perforated Gastric Ulcer in Two-Day-Old Infant. *Lancet*, November, 1929.
- ¹⁷ Rogers, J. S. Y.: Melena Neonatorum, *etc.* *Arch. Dis. Child.*, vol. iii, p. 163, 1928.
- ¹⁸ Nixon, J. A., and Fraser, A. D.; Peptic Ulcer in the New-Born. *Arch. Dis. Child.*, vol. iii, pp. 157-162, June, 1928.
- ¹⁹ Theile, P.: *Ergebnisse der Med. und Kindheilkunn*, vol. xvi, p. 303, 1919.
- ²⁰ Helmholz, H. F.: *Deutsch. med. Woch.*, vol. i, p. 534, 1909.
- ²¹ Moynihan: Second Edition, 1912.
- ²² Saunders, Edward Watts: A Bacteriological and Clinical Study of Gastric Ulcer. *ANNALS OF SURGERY*, vol. xcii, No. 2, pp. 222-233.
- ²³ Rosenow, E. C.: *Journal of Infectious Diseases*, vol. xix, pp. 333-384, 1916.
- ²⁴ Gerdine, L., and Helmholz, H. F.: *Amer. Jour. Dis. Child.*, vol. x, pp. 397-409, December, 1915.
- ²⁵ Kennedy: *Amer. Jour. Dis. Child.*, vol. xxxi, p. 631; 1926.
- ²⁶ Finny: *Pro. Royal Society Medicine*, p. 9, 1908.
- ²⁷ Pedrazzi, C.: *Arch. di Radiol.*, vol. iii, pp. 75-88, January-February, 1927.
- ²⁸ Henderson, W. F.: Duodenal Ulcers in Childhood. *New Orleans Med. and Surg. Jour.*, vol. lxxxiii, pp. 295-299, November, 1930.

PARTIAL GASTRECTOMY FOR LYMPHOSARCOMA IN CHILDHOOD *

BY VERNE C. HUNT, M.D.

OF LOS ANGELES, CALIF.

ALTHOUGH formidable surgical procedures in childhood are no longer unusual, one seldom sees a lesion in early childhood where a radical partial gastrectomy is indicated. Lymphosarcoma of the stomach is usually encountered in adult life, in which cases the operability of the lesion is perhaps higher than in cases of carcinoma of the stomach. The literature contains less than 400 cases of lymphosarcoma of the stomach found surgically and at autopsy. The earliest age at which lymphosarcoma of the stomach was ever encountered was in the case of a boy three and one-half years of age, reported by Finlayson,⁵ in 1899. In this instance, the diagnosis was made at autopsy. The case which I am reporting is presented because of the rarity of the lesion in childhood, and because it was discovered in the youngest child on record where a partial gastrectomy has been done for lymphosarcoma of the stomach with subsequent recovery of the patient.

THE CASE.—A boy, aged three years and eight months, was brought to St. Vincent's Hospital March 16, 1931. The boy had been perfectly well until three weeks previously, when he began vomiting. X-ray examination soon after onset of the vomiting showed pyloric obstruction, with dilatation of the stomach and hyperperistalsis. General examination of the child was negative, except for visible epigastric peristalsis. Twelve days prior to admission to the hospital, a mass became palpable in the upper abdomen. The vomiting had become projectile in type. There had been a weight loss of but four pounds.

He was a somewhat emaciated, dehydrated, and hollow-eyed child. A large dilated stomach, in which active peristalsis was visible, could be outlined. A mass about three centimetres in diameter was palpable at the pylorus, and a number of nodules could be palpated across the median line to the left, at about the greater curvature of the stomach. The physical examination was otherwise negative. Except for a trace of albumin, the urine was normal. The hæmoglobin was 70 per cent.; erythrocytes numbered 4,460,000; leucocytes, 7,350; lymphocytes, 76 per cent.; large mononuclears, 3 per cent.; and neutrophils, 18 per cent. March 18, 1931, exploration revealed a firm, rather diffuse lesion encircling the pylorus and involving the pyloric third of the posterior wall of the stomach. (Fig. 1.) There were a number of glands less than one centimetre in diameter along the greater curvature of the stomach, several of which were removed and proved to be inflammatory. A general abdominal exploration disclosed no extragastric involvement. A gastric resection was done, and the pyloric half of the stomach was removed, after which a posterior Polya type of anastomosis was made. The child's convalescence was most satisfactory and he was dismissed from the hospital on the fifteenth day after the operation. Subsequent X-ray therapy was carried out.

Pathological report of Doctor E. M. Hall: "Specimen consists of a tumor of the pyloric end of the stomach. It measures ten by five by two centimetres. The growth is cuneate in shape, with the base involving the entire pyloric sphincter. The proximal part extends tongue-like for seven centimetres, along the greater curvature and posterior wall

* Read before the Western Surgical Association, December 4, 1931.

GASTRECTOMY FOR CHILD SARCOMA

of the stomach. The growth is somewhat nodular, with smooth rounded edges. It appears to be covered with mucous membrane except for a small area near the proximal end, where there is a punched-out ulcer seven by ten millimetres in diameter and ten millimetres deep. The tumor varies from five millimetres to 2.5 centimetres in thickness. At the pylorus it is two centimetres thick. The tumor has a pale grayish-yellow color on its cut surface and is somewhat yellow on its external surface. The tumor stops sharply at the pylorus. Some of the solitary follicles in the duodenum are prominent.

"Sections of the tumor show an extremely cellular growth composed of diffuse cellular connective-tissue stroma, surrounding large atypical cells of lymphoid type. These are probably reticular cells of lymphoid tissue. Numerous mitoses are present. The growth is covered by atrophic mucous membrane, while the muscularis is almost destroyed by the

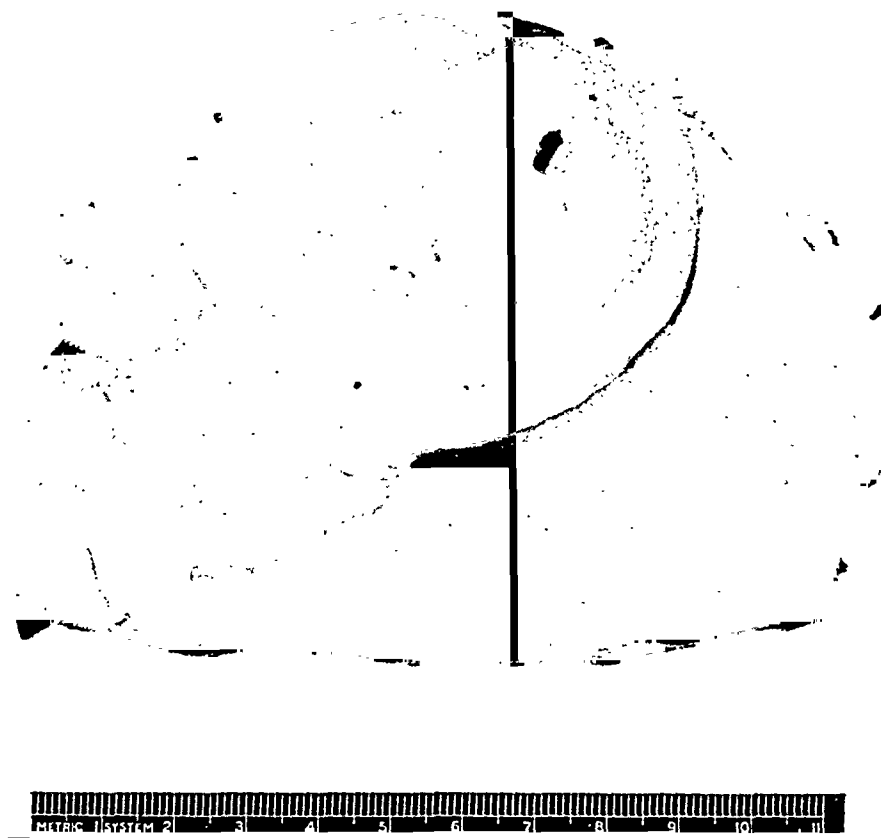


FIG. 1.—Photograph of pyloric half of the stomach containing lymphosarcoma, completely encircling the pylorus and involving the posterior wall of the stomach.

infiltrating tumor. Section of the lymph-nodes shows hyperplasia and hypertrophy of the follicles. They contain no tumor-cells. *Diagnosis*.—Lymphosarcoma of the stomach (pylorus)."

Comment.—The high percentage of lymphocytes in the differential count is of unknown significance. It is of interest that on the eighth day post-operatively the percentage of lymphocytes had decreased to 62 per cent., while the neutrophils had increased to 37 per cent. August 8, 1931, or nearly five months after the operation, a further reduction in lymphocytes to 43 per cent. had occurred, with an increase in neutrophils to 51 per cent. In August, the patient had some slight gastric disturbance. However, a physical examination of the child was negative, and an X-ray examination of the stomach by Dr. K. S. Davis¹ showed that the stomach emptied readily, and there was no

röntgenological evidence of recurrence. November 27, 1931, more than eight months after the operation, the boy was reported to me to be in good health.

Incidence of Sarcoma of the Stomach.—Less than 400 cases of sarcoma of the stomach are recorded in the literature. It has been estimated that sarcoma accounts for about 1 per cent. of the malignant lesions of the stomach. Bruch reported the first case in 1847; in 1914, Forni compiled a list of 200 cases from the literature. In 1920, Haggard⁷ collected 244 authentic cases of primary sarcoma of the stomach from the literature, 107 of which had been operated upon. In 1930, D'Aunoy and Zoeller⁴ reported four cases, and collected from the literature through 1929 cases seen since those compiled by Forni, to make a total of 335. In 1930, Balfour and McCann² reported fifty-four cases from The Mayo Clinic, which, when the proper deductions are made of cases previously reported—twelve cases by Haggard, and five cases by Broders and

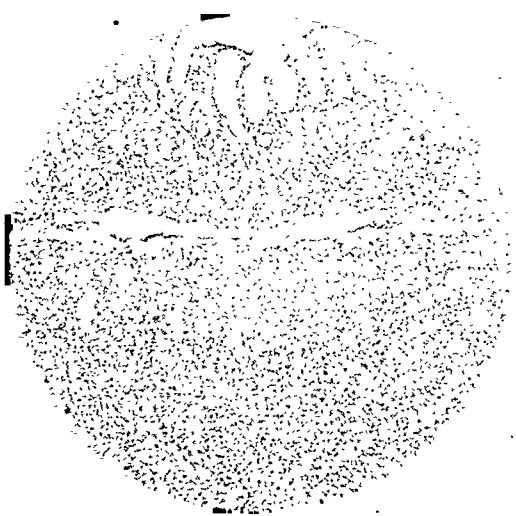


FIG. 2.—Low-power photomicrograph of lymphosarcoma of the stomach shown in Fig. 1.

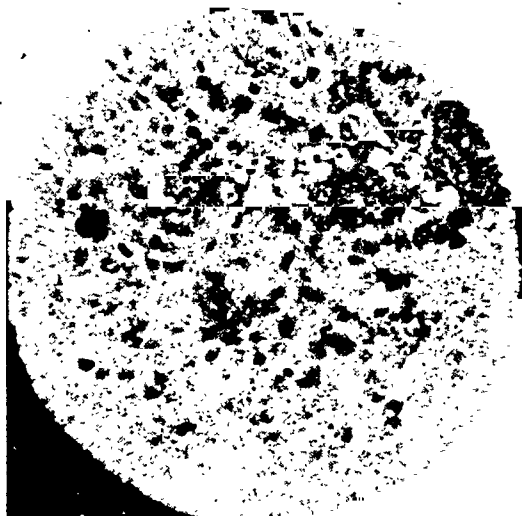


FIG. 3.—High-power photomicrograph of lymphosarcoma of the stomach shown in Fig. 1.

Mahle—add thirty-seven cases to those collected by D'Aunoy and Zoeller. Nine cases have been reported since that time by Schiff and Foulger⁹ (one), Coffey³ (one), Askey, Hall and Davis¹ (one), Reeves⁸ (two), and Gatewood⁶ (four). There are recorded in the literature approximately 381 cases of sarcoma of the stomach. For the most part this material has been adequately analyzed by Forni, D'Aunoy and Zoeller, Haggard, Balfour and McCann, and Askey, and careful deductions and conclusions have been recorded.

A diagnosis of sarcoma of the stomach is seldom made pre-operatively, and an exploration is usually done after a diagnosis of carcinoma of the stomach, tumor of the stomach, or abdominal tumor has been made. There is nothing characteristic of sarcoma to assist in making such a pre-operative diagnosis with any degree of certainty. Usually, the diagnosis is made only on section and microscopical study. Pathologists may experience considerable difficulty in determining the type of sarcoma and differentiating the lesion

from Hodgkin's disease or isolated lymphogranulomatosis of the stomach. Singer¹⁰ recently reported a case of the latter, with a discussion of only seven other similar cases in the literature.

Practically all types of sarcoma occur in the stomach. However, lymphosarcoma is encountered most frequently. Lymphosarcoma accounted for 22 per cent. of the cases of sarcoma of the stomach studied by Haggard; 39 per cent. of the cases reviewed by D'Aunoy and Zoeller were lymphosarcoma, and this type of sarcoma was present in 59 per cent. of the cases reported by Balfour and McCann.

It is of interest that sarcoma of the stomach occurs earlier in life than carcinoma. The average age of patients with sarcoma of the stomach reported in the literature is about forty-one years, as compared with an average age of sixty-one years in patients with carcinoma of the stomach. The oldest patient, reported by di Giacoma, was ninety-one years of age, and the youngest, reported by Finlayson, was three and one-half years of age. While sarcoma of the stomach may occur in relatively young adults, approximately only 5 per cent. of the cases reported have been patients under twenty years of age, and in most instances when the disease has occurred in the second decade of life it has been after the fifteenth year. A review of the literature reveals extreme rarity of sarcoma of the stomach in the first decade of life. Unfortunately, the age had not always been included in the case reports. It has been possible to find recorded but two cases of patients less than ten years of age. D'Aunoy and Zoeller included but one patient under ten years of age and that was a child of eight years reported by Demel in 1924. The youngest patient in the series reported by Balfour and McCann was ten years of age. In 1899, Finlayson reported a case of sarcoma of the stomach in a boy three and one-half years of age, the youngest child on record. At that time, the author stated he had been unable to find records of any definite case of sarcoma of the stomach in a young child.

In general, the operability of sarcomatous lesions of the stomach is probably greater than in instances of carcinoma. Balfour and McCann reported an operability of 66 per cent. in their series. In the series of cases studied by D'Aunoy and Zoeller, excluding the cases therein reported from The Mayo Clinic by Haggard, and those by Broders and Mahle, which are included in the series of Balfour and McCann, it is noted in the cases in which details are included that seventy-six cases were subjected to exploration, with surgical removal by some type of gastric resection or excision in sixty-three cases, an operability of 82 per cent., with a surgical mortality rate, however, within thirty days of approximately 14 per cent. The prognosis in cases of sarcoma of the stomach seems to be somewhat more favorable than that in cases of carcinoma of the stomach. In many instances, this is due to pedunculation of the lesion. Certain types of sarcoma are not infiltrating in type but have sharp demarcation and definite limitation of involvement, which favors radical removal, with total exclusion of the lesion. Balfour and McCann report approximately 32 per cent. of the patients living after a period of years. The longest

duration of life in one case was nine years when last heard from. Haggard found approximately 64 per cent. of sixty-four cases collected from the literature where the patients were living and well after a period of years. The longest duration of time in one case was ten years. In 1921, Lendon reported a case of round-cell and spindle-cell sarcoma of the stomach where the patient was living and well eleven years after local excision of the lesion. Post-operative irradiation perhaps exerts some influence on the prognosis. Des Jardines has stated that lymphosarcomata are the most favorable of the sarcomata for Röntgen-ray treatment. The high percentage of operability and the relatively satisfactory results obtained through surgical removal of localized, definitely demarcated sarcomata of the stomach, gives encouragement to radical surgical endeavor in the treatment of sarcoma of the stomach.

SUMMARY.—A case of lymphosarcoma of the stomach in a child aged three years and eight months is presented, in which pyloric obstruction with projectile type of vomiting characterized the onset of symptoms. A partial gastrectomy, with a posterior Polya type of anastomosis, was made, with recovery of the child. After a careful search of the literature, it is believed that this case is the earliest age at which radical surgical removal of a sarcoma of the stomach has been recorded.

BIBLIOGRAPHY

- ¹ Askey, E. V., Hall, E. M., and Davis, K. S.: Sarcoma of the Stomach. *Western Jour. of Surg., Gynec., and Obst.*, vol. xxxix, pp. 839-847, November, 1931.
- ² Balfour, D. C., and McCann, J. C.: Sarcoma of the Stomach. *Surg., Gynec., and Obst.*, vol. xxxi, No. 5, pp. 505-511, November, 1920.
- ³ Coffey, Henry D.: Sarcoma of the Stomach. *U. S. Veterans' Bureau Med. Bull.*, vol. vi, No. 8, pp. 703-704, August, 1930.
- ⁴ D'Aunoy, R., and Zoeller, A.: Sarcoma of the Stomach. *Amer. Jour. Surg.*, vol. ix, No. 3, pp. 444-464, September, 1930.
- ⁵ Finlayson, James: Case of Sarcoma of the Stomach in a Child Aged Three and a Half Years. *Brit. Med. Jour.*, vol. ii, pp. 535-536, 1899.
- ⁶ Gatewood: Post-operative Results in Malignancies of the Stomach. *Trans. West. Surg. Assn.*, pp. 349-364, 1930.
- ⁷ Haggard, William D.: Sarcoma of the Stomach. *Surg., Gynec., and Obst.*, vol. xxxi, No. 5, pp. 505-511, November, 1920.
- ⁸ Reeves, Robert J.: Sarcoma of the Stomach. *Radiology*, vol. xv, No. 5, pp. 567-573, November, 1930.
- ⁹ Schiff, L., and Foulger, M.: A Case of Leiomyo-sarcoma of the Stomach. *Jour. Amer. Med. Assn.*, vol. xcvi, p. 942, March 21, 1931.
- ¹⁰ Singer, Harry A.: Primary, Isolated Lymphogranulomatosis of the Stomach. *Arch. Surg.*, vol. xxii, pp. 1001-1017, June, 1931.

PSEUDOMYXOMA PERITONEI*

By JOHN W. JEFFRIES, M.D.

OF PHILADELPHIA, PA.

Two cases of pseudomyxoma peritonei in the male with a brief review of the disease are reported.

CASE I.—F. S., white male, aged forty-eight years, was admitted to the surgical service of the Lankenau Hospital August 13, 1930, complaining of abdominal pain. He states that twenty-four hours prior to admission he developed acute epigastric pain which was very severe. The pain improved during the night but next morning the pain was confined to the right lower quadrant. He took a physic which increased his pain. He had no nausea or vomiting, but he had no appetite. His general health was always good except for chronic constipation during the past several years. His temperature when admitted was $100 \frac{4}{5}$; pulse 86 and respirations 18; a normal blood-pressure; normal hæmoglobin and red cell count; a leucocytosis of 15,600 with 64 per cent. polymorphonuclears, 30 per cent. lymphocytes and 6 per cent. large mononuclears. The blood sugar and urea were normal. The abdomen revealed evidence of a mass in the right iliac fossa with overlying tenderness and rigidity. Peristalsis was diminished. The pre-operative diagnosis was appendiceal abscess. Operation done under spinocaine through a low right rectus incision revealed a palpable mass in the right iliac fossa, completely covered with great omentum. This area was well packed off with rubber dam and gauze pads. The omentum was then raised, revealing a large collection of whitish-yellow semi-gelatinous material. This was removed leaving a cavity, which could contain a large grapefruit. A short, thick, acutely inflamed appendix, which did not appear to be perforated, was removed from the centre of this cavity by transfixing the base and ligating. The cæcum was found perforated at two points near the base of the appendix. These perforations were oversewn. Two large cigarette drains containing rubber tubes were placed in the cyst cavity and were surrounded with rubber dam. Incision was closed to drainage. The pathological report of the appendix was "chronic obliterating appendicitis with secondary columnar cell carcinoma in the lymphatics of the serosa." This patient developed a cæcal fistula on the fifth post-operative day. He was discharged thirty-two days after operation. He was healed except for a small area of granulations in his scar. He has been perfectly well since leaving the hospital and is now employed as a hospital orderly.

CASE II.—A. M., white male, aged sixty-seven years, was admitted to the surgical service of the Lankenau Hospital September 2, 1930, with the chief complaint of abdominal distention. The only facts of importance in his history were: Several attacks of belching of brackish material two years ago, slight constipation and some frequency of urination during the past eighteen months. The abdominal mass was revealed over a year ago while undergoing a physical examination for rheumatic shoulders. He was X-rayed shortly after, revealing a mass in the right lower abdomen exerting considerable pressure on the cæcum and terminal ileum and perhaps involving or arising from these structures. Operation at that time was decided against by his physician.

Upon admission to the hospital, his clinical analyses were within normal limits. Pre-operative diagnosis was mesenteric cyst. At operation September 6, 1930, under spinocaine anæsthesia, through a low right rectus incision, upon opening the peritoneum a large cyst was exposed occupying the entire lower abdomen and pelvis. The remainder

* Read before the Philadelphia Academy of Surgery, January 4, 1932.

of the entire greater peritoneal cavity was involved by the pseudomucinous process. The cyst was attached in the right iliac fossa and the appendix could not be identified. About two litres of gelatinous material, amber in color, was removed from the cyst and about the same amount from the free peritoneal cavity. The abdomen was irrigated with normal saline in order to wash out more pseudomucin. Three large rubber tubes were inserted into the upper abdomen and held in place by catgut sutures. The cyst wall was partly closed and a perforated glass tube drain was placed in its lowest portion. The abdominal wall was closed loosely with long interrupted through-and-through heavy linen sutures and the wound packed loosely with gauze. On the fourth day post-operatively all drainage was removed and sutures tightened so as to close the wound tightly. The wound healed primarily and the sutures were removed on the twenty-second post-operative day. There were no complications. The patient was discharged twenty-six days after operation with an uneventful convalescence. The follow-up service reports that the patient is now enjoying good health. The only illness that he has had since operation was a spell of fever and jaundice lasting one month.

Pseudomyxoma peritonei, sometimes referred to as mucous ascites, is a comparatively rare disease occurring most often in women secondary to ruptured pseudomucinous ovarian cysts. It is more rare in the male, the above cases constituting the twelfth and thirteenth to have been reported in the literature. The term was originated by Werth in 1884, although Peon, in 1871, was probably referring to this disease when he described "myomatous degeneration of the peritoneum." Fraenkel, in 1901, was the first to report this disease in the male and to give a full description of it. Olshausen, in 1884, was the first one to publish the correct opinion as to the origin of pseudomyxoma peritonei. He believed it due to a transplantation of epithelial cells from ruptured cyst walls to the peritoneum.

Pseudomyxoma peritonei is clinically a fatal disease although pathologically it may be malignant or benign. Of all cases fully reported, about 62 per cent. were benign while the remaining 38 per cent. were malignant pathologically. It may originate secondary to ruptured pseudomucinous ovarian cystadenomas or from a ruptured mucocoele of the veriform appendix. There have been cases reported in which the authors believed the condition to have originated in the gall-bladder, colonic appendages, great omentum or the omphalomesenteric duct. Pseudomyxoma peritonei has been produced experimentally in rabbits by ligating the appendix and cutting distal to the ligature.

The average age incidence of this disease is late in the fourth decade but it has occurred in patients ranging in age from eighteen to eighty-five years. The average duration of life after operation is between four and five years. One patient is reported living twelve years after operative diagnosis. Several cases have been reported to have had as many as five operations for the mechanical removal of pseudomucin.

The symptomatology of pseudomyxoma peritonei is varied. The only constant symptom is abdominal distention. In about 50 per cent. of the cases on record, abdominal pain was a symptom. Acute pain occurs in these cases only when due to an acute inflammatory process. As the pseudomucin increases, pressure symptoms arise such as constipation, dyspnoea, bearing-

PSEUDOMYXOMA PERITONEI

down sensations and frequency of urination. Several cases are on record having been correctly diagnosed before operation either by physical examination or paracentesis abdominæ.

In either case of primary source, the pseudomyxoma peritonei is caused by a transplantation and continued growth of low or high columnar cells cast off from the lining of the cyst or mucocele, as the case may be. The transplants may form multiple localized pseudomucinous cysts, a homogeneous, free-lying formation of pseudomucin or a combination of these processes. There is usually evidence of a marked attempt of the intra-abdominal organs to localize these processes by adhesions. Cases are on record in which these transplants are said to have perforated bowel and blood-vessels.

Death in the pathologically benign type of pseudomyxoma peritonei may be due to various causes such as: bowel perforation, perforation of large blood-vessels, obstructive pressure of various-sized cysts on hepatic ducts or other important organs, and cachexia. The pathologically malignant type excepting primary carcinoma of the appendix, causes death as does other intra-abdominal carcinoma.

The prognosis for patients who have pseudomyxoma peritonei, secondary to ruptured mucocele of the appendix, is better than in those secondary to ovarian cysts. Appendiceal mucocele occurs much more frequently in the male than in the female. These cases peculiarly reveal a leucocytosis of between 14,000 and 16,000 and are most often pre-operatively diagnosed as appendiceal abscess.

The chemical analysis of the gelatinous material removed from these cases is typically that of pseudomucin. It is sterile, containing a network of fibrinous material, and occasionally living cells with their processes. The chemical reaction of this material is acid when its origin is appendiceal, mucocele and alkaline when from ovarian cyst. The color may vary from a light amber, through cloudy dark amber to a dark cherry red.

The operative mortality in pseudomyxoma peritonei is due either to shock, pulmonary embolus or to peritonitis.

All cases should have deep radiotherapy following operation and they should not be drained unless otherwise indicated because of their extreme susceptibility to developing peritonitis.

BIBLIOGRAPHY

- ¹ Cleveland, J. B., and Sleeman, J. A.: *Med. Jour. Australia*, vol. i, p. 721, May 14, 1927.
- ² Deaver, J. B.: *Jour. Am. Med. Assn.*, vol. xci, pp. 1008-1928.
- ³ Fraenkel, E.: *München Med. Wchnschr.*, vol. lxxviii, pp. 965-970, 1901.
- ⁴ Giardina, S. G.: *La Reforma Med.*, vol. xxxviii, pp. 1209-1922.
- ⁵ Hughens, H. V.: *U. S. Nav. Med. Bull.*, vol. xxviii, pp. 618-621, July, 1930.
- ⁶ Mason, J. C., and Hamrick, R. A.: *Surg. Clin. N. A.*, pp. 61-75, February, 1930.
- ⁷ Mason, J. C., and Hamrick, R. A.: *Surg., Gynec. and Obstet.*, vol. 1, pp. 1023-1029, June, 1930.

- ⁶ Mason, J. C., and Hamrick, R. A.: *Canad. Med. Assn. Jour.*, vol. xxii, p. 508, April, 1930.
- ⁹ Michaelson, E.: *Acta. Chir. Scandin.*, vol. liii, pp. 441-1920, 1921.
- ¹⁰ Michaelson, E.: *Acta. Chir. Scandin.*, vol. lxxviii, p. 25, 1931.
- ¹¹ McCrae, T., and Choplin, W. M. L.: *Am. Jour. Med. Sc.*, vol. clxi, p. 475, 1916.
- ¹² Naeslund, J.: *Upsala Läkoref, Förh.*, vol. i, pp. 1-219, 1928.
- ¹³ Olshausen, R.: *Ztschr. f. Geburtsh. u. Gynäk.*, vol. xi, p. 238, 1884.
- ¹⁴ Peon: Quoted by Lehmann, K.: *Hospitalstid*, vol. lxix, p. 326, 1926.
- ¹⁵ Southey, M. V., and Webster, R.: *Med. Jour. Australia*, vol. i, p. 703, June 19, 1926.
- ¹⁶ Trotter, W.: *Brit. Med. Jour.*, vol. i, p. 687, 1910.
- ¹⁷ Werth: *Arch. f. Gynaek.*, vol. xxiv, pp. 100-118, 1884.

CHRONIC OBSTRUCTION OF THE DUODENUM CAUSED BY ENLARGED RETROPERITONEAL GLANDS

BY RAWLEY M. PENICK, JR., M.D.

OF BALTIMORE, MD.

FROM THE DEPARTMENT OF SURGERY OF THE JOHNS HOPKINS UNIVERSITY AND HOSPITAL

DUODENAL obstruction has received much attention during the last few years, many individual as well as series of cases having been reported. It is safe to say, however, that the etiological factor in many of the reported cases is still open to question and the part played by compression of the bowel by the mesenteric vessels has not been thoroughly evaluated in spite of the fact that this factor has been discussed frequently. Therefore, the following cases are reported because in each a definite obstruction of the duodenum was produced by a pathological process that has not been previously considered as of etiological significance.

The literature has been extensively reviewed by Kellogg. Rokitsky¹ was apparently the first to suggest that acute dilatation of the stomach could be produced by compression of the duodenum by the mesenteric vessels. Fagge² described the symptoms and post-mortem findings in 1873; one of his cases was due to a retroperitoneal abscess, probably arising from a perforated ulcer of the duodenum. Albrecht,³ in 1899, reported two more cases and noted a flattening of the gut between the mesenteric vessels and the spine; this led him to experiment with traction on the mesentery and he concluded that obstruction could be produced in this manner. Conner⁴ later did similar experiments on the cadaver and arrived at the same conclusion. Robinson,⁵ Conner, Codman,⁶ Kellogg,⁷ and Higgins⁸ have contributed excellent reviews of the subject, laying stress particularly on chronic ileus. Bloodgood,⁹ Finney,¹⁰ and others have discussed the subject in relation to acute dilatation of the stomach.

Practically all of the writers referred to have considered duodenal compression by the superior mesenteric vessels as an important etiological factor in both chronic duodenal ileus and in acute dilatation of the stomach; however, there have been dissenting voices, particularly those of Robertson¹¹ and of Devine.¹² The latter thinks a dysfunction of the neuromuscular mechanism is responsible in some cases, and Robertson rejects completely pressure by the mesentery as a cause. A classification of causes given by Higgins does not seem to be sufficiently comprehensive. If all the best-known theories and facts are included, they may be tabulated as follows:

- (1) Congenital anomalies.
- (2) Obstruction within the bowel (tumors, foreign bodies, constrictions).
- (3) Obstruction from without (abnormal masses, compression by mesenteric vessels).
- (4) Adhesions causing deformity and reduced motility.

(5) Neuromuscular dysfunction (toxic, Robertson; unknown origin, Devine).

In this communication we are interested primarily in the third group and particularly in the cases in which pressure from without is caused by abnormal masses. This has received scant attention but it occurs not uncommonly with pancreatic tumors, such as carcinoma arising in the head of the gland as well as with pancreatic cysts. Probably retroperitoneal tumors cause duodenal obstruction more often than is suspected, and that pressure may be exerted by neighboring neoplasms is well known. Recently Wantoch¹³ has reported two patients with obstruction at the duodeno-jejunal junction caused by tuberculous glands. There is no mention of dilatation above this point, and treatment consisted in removing the glands.

I wish to report two cases of duodenal obstruction in the region of the mesenteric attachment produced by enlarged lymph-glands containing calcification due, presumably, to tuberculosis.

CASE I.—U-30,960. M. S., sixty years old, a white woman, was admitted to the hospital in May, 1930, complaining of "stomach trouble." The family history was negative for malignant disease, tuberculosis, and diseases of the blood. Her general health had been fairly good; in addition to the usual infections of childhood she had pneumonia at twelve years and influenza one year ago. There is also a history of malarial fever in childhood.

The present illness began one year ago when the patient began to have periods of nausea accompanied by occasional vomiting. These symptoms were not related to meals. The vomitus contained bile. She soon noticed anorexia, weakness, and fatigability, and three months ago the first actual pain occurred in the form of cramp-like pain in the epigastrium. Since that time attacks of pain have been frequent and often accompanied by a "rumbling noise" in the abdomen. Soda gives no relief. Recently her feet have felt cold and numb. There has been a loss of forty-five pounds in weight during the year.

Examination.—Temperature, 98.6°; pulse, 88. The patient is a poorly developed, thin woman who appears weak and anæmic. The skin and mucous membranes are pale but otherwise normal. No stomatitis. The abdomen is flat and symmetrical; on palpation definite rigidity is found in the epigastrium and some diffuse tenderness, especially toward the right. No abnormal masses can be felt. The entire abdomen is tympanitic but this is more noticeable in the epigastrium. The spleen is not palpable, and the general examination of heart and lungs as well as the neurological examination is negative.

Laboratory Findings.—Hæmoglobin, 57 per cent. White blood-cells, 6000. Red blood-cells, 4,100,000. Differential and smear show nothing except secondary anæmia. Wassermann negative. Stool is very light brown; contains bile but no occult blood. Gastric analysis after histamine shows free hydrochloric acid 0, total hydrochloric 15.

X-rays with Barium Meal.—Fluoroscopic examination showed a forty-eight-hour retention, pylorus slightly irregular, striking dilatation of duodenum. (Fig. 2.) The impression from a study of films was: Stomach normal, duodenum dilated, forty-eight-hour retention; these findings indicate a mass on the posterior wall of the stomach or a tumor in the region of the pancreas. *X-rays of the Chest.* Numerous calcified nodules in left apex, indicating an old tuberculous lesion.

Operation (Doctor Lewis, May, 1930).—The stomach was found somewhat dilated, but there was a greater dilatation of the duodenum. There was no evidence of ulcer. No obstruction could be found in the first and second portions of the duodenum, but

CHRONIC OBSTRUCTION OF DUODENUM

at its junction with the jejunum a mass could be seen pushing up from behind the bowel, which was flattened over it. On palpation the mass was found to be nodular and partially calcified. It was the impression at the time that this represented enlarged glands, probably tuberculous in origin. An attempt to excise the mass in part or as a whole was considered inadvisable when it was found to be densely adherent over the vena cava and to the pancreas.

An anterior gastroduodenojejunostomy was done; the stoma began on the stomach, crossed the pylorus, and extended well into the duodenum. An entero-enterostomy was done then between the two loops of jejunum.

Post-operative Course.—The patient made a satisfactory recovery. Vomiting occurred only twice after the operation, and she was discharged twenty-two days later, relieved of her abdominal symptoms.

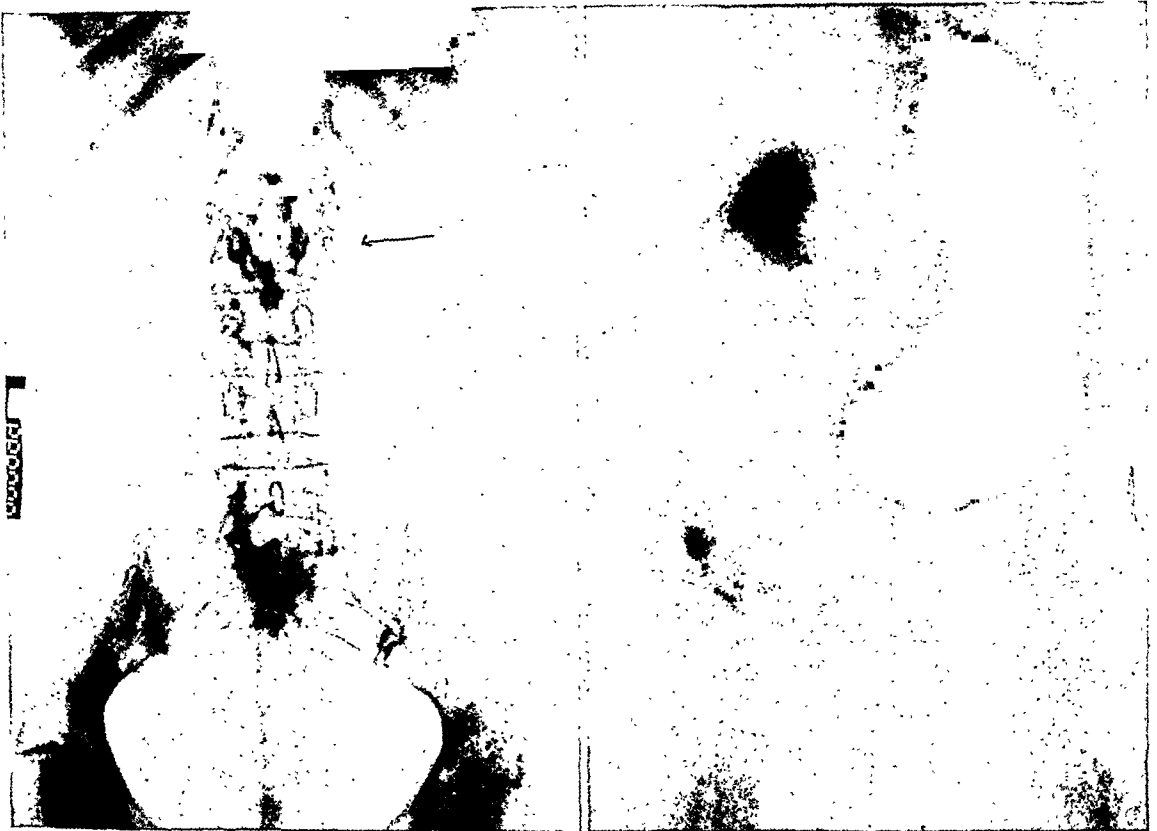


FIG. 1.

FIG. 2.

FIG. 1.—Case I. Showing calcification of the retroperitoneal glands.

FIG. 2.—Case I. Showing dilatation of the duodenum and retention of barium at the end of five hours.

Subsequent Course.—The patient was readmitted three weeks later complaining of weakness and numbness of the legs; there had been no recurrence of abdominal symptoms and she had gained weight. An extensive study was made, and in addition to the findings already noted, it was found that there were now slight sensory changes in the legs, and X-rays revealed some calcification in the retroperitoneal glands. (Fig. 1.) The administration of liver caused only a slight hæmatopoietic response. Her third admission was in June, 1931, when she returned to the medical service because of symptoms associated with anæmia and occasional vomiting. X-rays showed that some dilatation of the duodenum persisted. The abdominal symptoms improved under symptomatic treatment.

In October, 1931, the patient returned again; weakness, anæmia, and neurological signs persisted, and in addition vomiting had recurred recently. X-rays at that time showed dilatation of the duodenum and also of the proximal portion of the jejunum. A second operation was thought warranted.

Operation (Doctor Lewis, October, 1931).—The nodular mass pressing up from behind the third part of the duodenum was evident; however, the arms of the jejunal loop appeared bound down to the mass, and there was little doubt that the existing obstruction resulted from this because the jejunal loops proximal to it were dilated. Another loop of small bowel was brought up and another gastroenterostomy and entero-enterostomy were done.

Course.—After operation she was greatly improved; she now has no gastro-intestinal symptoms and has gained 15 pounds in weight.

CASE II.—U-39,910. J. B., forty-nine years old. A white man who had had pain in the abdomen for five months. Both father and mother died of pneumonia. The patient's general health had been excellent prior to the present illness. He had the usual childhood diseases and scarlet fever at the age of fourteen. In 1914, an attack of



FIG 3—Case II. The barium is concentrated in the first portion of the duodenum and below it a partial obstruction exists

abdominal pain, diagnosed appendicitis, incapacitated him for forty days. He was not operated on at that time. He had influenza in 1918. Five months prior to his admission to the hospital he began to have cramp-like abdominal pain coming on usually about fifteen to twenty minutes after eating. The pain began usually below the umbilicus and radiated to both flanks; there was frequent nausea but no vomiting at any time. His appetite is poor, and he has excluded articles of food from his diet so at present he takes practically nothing but toast and eggs. SIX weeks ago an attack of diarrhoea lasted several days, and at that time the stools were light-colored. Lately the pain has become worse, and he has lost forty pounds since the onset of his symptoms.

Examination.—Temperature, 97.8°. Pulse, 80. The patient is a middle-aged man whose skin is of good color; he shows evidence of recent loss of weight. The general examination reveals nothing of interest except a moderate arteriosclerosis and some enlargement of the prostate. The abdomen is flat; there is no distension or asymmetry.

CHRONIC OBSTRUCTION OF DUODENUM

The liver is not enlarged; half-way between the umbilicus and the right costal margin there is a tender area where an ill-defined, soft intra-abdominal mass can be felt, the edge of which cannot be outlined definitely.

Laboratory Findings.—White blood-cells, 8000. Hæmoglobin, 90 per cent. Stool clay-colored, negative for bile but positive for occult blood. Gastric analysis with histamine shows free hydrochloric acid of 24 and a total acidity of 52.

X-rays.—Fluoroscopical examination shows no obstruction at the pylorus; however, the duodenum is displaced, suggesting that it encircles a mass. The films show a partial obstruction, with dilatation; no lesion in the stomach. (Fig. 3.)

Operation (Doctor Lewis, October, 1931).—The first portion of the duodenum was considerably dilated because of an obstruction by a mass of calcified glands that almost surrounded the gut in this region. It was thought the process represented an old tuberculosis of the retroperitoneal lymph-glands. As the mass was densely adherent to the pancreas its removal was not attempted but a small piece was excised for section. An anterior gastroenterostomy was done in addition to an entero-enterostomy between the two arms of the jejunal loop.

Pathological Report.—The sections showed a calcified nodule surrounded by a capsule of fibrous tissue in which a chronic inflammatory cellular reaction was present. There was no other evidence of tuberculosis.

Post-operative Course.—The patient stood the operation well. The day after operation there was some vomiting and gastric lavage was resorted to; this was repeated, but when the vomiting stopped and only small amounts of fluid were obtained it was discontinued. On the third day the temperature rose to 102°, pulse 130, and the following day signs of pneumonia were present at both bases. The abdomen remained soft, but the patient became worse and died on the seventh day as the result of the pulmonary infection. Unfortunately, permission for autopsy was refused.

Comment.—The symptomatology of these cases presents nothing unusual. It is worthy of emphasis, however, that in both cases the obstruction of the duodenum and the accompanying dilatation did not extend below that portion of the digestive tube and in each instance the dilatation was marked and was diagnosed by X-ray before operation. Active tuberculosis could not be demonstrated elsewhere, but the glands involved contained extensive calcification.

The fact should not be overlooked that in Case I the actual mechanism of obstruction may be one similar to mesenteric ileus because the process may be interpreted as an instance in which the duodenum was pushed forward by the firm mass behind it and compressed between it and the mesenteric root. It has been suggested frequently that lordosis plays a similar rôle by narrowing the space between the spine and the mesenteric vessels, thus favoring compression of the bowel between them. In this case the obstruction was in the region of the vessels and the duodenum was "flattened over it." In the second case this factor can be excluded because the obstruction could be seen definitely at the junction of the first and second parts of the duodenum and was caused by the glands actually encroaching on the bowel.

The end-result of the first case was complicated by grave anæmia. The lymph-nodes appeared to have decreased in size in the interval between operations. The mass at the duodeno-jejunal angle had become calcified, maintaining the obstruction. The calcified mass can be seen in Fig. 1. The

arrow indicates the position. Death from pneumonia makes it impossible to draw conclusions as to the efficacy of operation in the second case.

SUMMARY.—Duodenal obstruction due to the presence of enlarged, calcified retroperitoneal glands has received little attention in the literature on this subject. Two such cases are reported. In both instances the obstruction and resulting dilatation were revealed by X-ray examination and confirmed at operation. Gastroduodenojejunostomy was done in one case and an anterior gastroenterostomy in the other. One patient developed a subsequent obstruction in the jejunum below the site of anastomosis which was due to adhesions between the gut and the glandular mass. Although the enlargement and calcification of the retroperitoneal glands were thought to be due to a tuberculous process, this was not confirmed by microscopical examination of the tissue removed or by the presence of active tuberculosis elsewhere. However, the presence of calcified pulmonary nodules in one case lends weight to this assumption.

BIBLIOGRAPHY

- ¹ Rokitsansky: Lehrbuch der path. Anatomie, 3. Aufl., Bd. iii, 1863.
- ² Fagge: Guy's Hosp. Reports, vol. xviii, 1873.
- ³ Albrecht: Virchow's Arch. f. path. Anat., Bd. ci, p. 285, 1849.
- ⁴ Conner: Tr. Assn. Am. Phys., vol. xxi, p. 579, 1906.
- ⁵ Robinson, B.: Cincinnati Lancet Clinic, vol. xlv, p. 577, 1900.
- ⁶ Codman: Boston Med. and Surg. Jour., vol. clviii, p. 503, 1908.
- ⁷ Kellogg: ANNALS OF SURGERY, vol. lxxiii, p. 578, 1921.
- ⁸ Higgins: Arch. Surg., vol. xiii, p. 1, 1926.
- ⁹ Bloodgood: ANNALS OF SURGERY, vol. xlv, p. 736, 1907.
- ¹⁰ Finney: Boston Med. and Surg. Jour., vol. clv, p. 107, 1906.
- ¹¹ Robertson, G.: Surg., Gynec., and Obst., vol. xl, p. 206, 1925.
- ¹² Devine: *Ibid.*, vol. xl, p. 1, 1925.
- ¹³ Wantoch: Deut. Ztschr. f. Chir., vol. ccxxvi, p. 135, 1930.

GRAVITY FEEDING BY JEJUNOSTOMY

BY JOHN D. STEWART, M.D.

OF BOSTON, MASS.

FROM THE SURGICAL SERVICE, THE MASSACHUSETTS GENERAL HOSPITAL

JEJUNOSTOMY feeding has proved to be of great value in a variety of conditions that may be encountered in the surgery of the upper abdomen, such as gastrojejunal ulcer, malfunctioning gastroenterostomy, extensive carcinoma of the stomach, and in post-operative treatment of patients after gastric resection.^{2, 7, 8} In cases of persistent biliary and external duodenal fistulæ jejunostomy feeding is sometimes a life-saving measure, since by this procedure the patient can be given a sufficient quantity of water, salt solution, and food, and also have restored the collected bile, pancreatic, and gastric secretions so essential to recovery.^{3, 4, 5, 6} Under these circumstances, successful jejunostomy feeding requires the introduction of at least 2,000 cubic centimetres of fluid in twenty-four hours. By the method in common use, the frequent injection of small amounts with a syringe, this quantity of fluid cannot be introduced into the jejunum without disturbing the rest and comfort of these very sick patients, as is shown by a study of the cases in which the method was used at the Massachusetts General Hospital during the past twelve years. Pain and even reflex vomiting from distention of the loop of jejunum containing the catheter may be produced by the injection, so that at times patients have refused to allow the injections to be made. By the gravity method, on the other hand, large amounts of fluid, even up to ten litres per day, can be given with ease, as will be illustrated by a case to be reported below. In the last two years the gravity method of jejunostomy feeding has been satisfactorily used at the Massachusetts General Hospital in a number of instances. Search of the literature shows that this method was first mentioned by Kelling,¹ and was referred to in a paper by Colp⁵ on external duodenal fistulæ.

Gravity feeding by jejunostomy requires but a simple apparatus. A two-litre container kept properly warmed is suspended at the head of the bed higher than the patient's body and is connected with the jejunostomy catheter by a soft rubber tube. A Murphy drip bulb is incorporated into the system, and a clamp for regulating the rate of flow is fastened to the tube proximal to the drip bulb. A slow continuous stream of fluid is supplied to the intestine and is taken up by peristaltic action as fast as the fluid is received. In this connection, it is important in performing jejunostomy to insert the catheter for at least half its length into the bowel in order that peristalsis of the jejunum at the end of the catheter may be as little interfered with as possible. The peristalsis of the upper jejunum of the dog exerts, as Alvarez⁹ has demonstrated, a pull sufficient to sustain a weight of over 200 grams. In one patient a soft rubber tube was used to connect the reservoir and the jejunum and intermittent collapse of the tube, presumably from the pull of

jejunal peristalsis, was noted. The rate of flow through the jejunostomy tube from the reservoir is regulated by adjusting the clamp on the tube so that the amount of fluid to be given in one day runs in continuously in the course of twenty-four hours.

Feeding through jejunostomy can be started immediately after the operation. All the necessary nutritional elements can be given and in abundance. Fluids of high caloric value, such as glucose or lactose solutions, and milk and

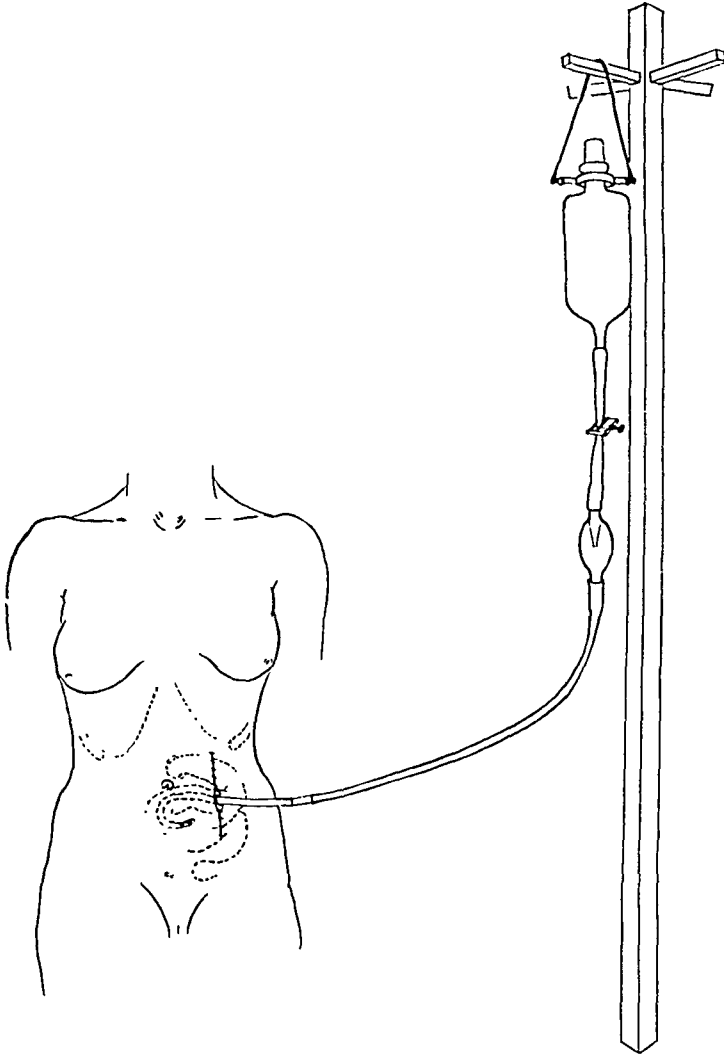


FIG. 1.—Note distance catheter is inserted into jejunum.

cream, are well borne. Ground meat, eggs, and peptonized milk may be given to supply essential amino acids. Vitamines, important in the treatment of many surgical patients, can be administered by feeding yeast concentrate, tomato juice, cod-liver oil, viosterol, and strained vegetables. A hæmatoplastic regimen in which vitamines, liver, and iron have their place is often indicated and is easily maintained.

The amount and character of the fluid to be supplied the jejunum will vary, of course, with the individual case. Such factors as the degree of

GRAVITY FEEDING BY JEJUNOSTOMY

dehydration and malnutrition, the amount vomited, the nature of the underlying disease, the size and age of the patient, and what is being taken by mouth determine the need to be met by jejunostomy feeding. As a rough guide it may be considered that the average adult patient should have three to four litres of fluid and three to four thousand calories daily, remembering that the protein, vitamine, and mineral salt requirements also must be met. In cases of external fistula communicating with the upper alimentary canal, such as biliary, gastric, or duodenal fistula, the discharges should be collected by constant suction and put into the gravity feeding reservoir.

The complications and ill effects of jejunostomy feeding by the gravity method are few. Leakage around the catheter and irritation of the skin may develop if the jejunostomy is put to prolonged use. Should the catheter accidentally be withdrawn from the jejunum it should be replaced within forty-eight hours, as the fistulous tract produced by the Witzel technic closes promptly. A mild diarrhoea sometimes results on a hyper-feeding régime. The studies of Scott and Ivy¹⁰ on jejunostomy feeding in dogs led them to conclude that diarrhoea was due to excess of fat in the diet or to the irritating effect of raw fruit juices when introduced into the jejunum. Whether this conclusion is applicable to man is uncertain. In treatment of the diarrhoea opium derivatives or salts of bismuth and calcium may be given by the jejunostomy with alteration of the diet as indicated.

In the following illustrative case gravity feeding by jejunostomy was found invaluable.

R. L., a thirty-three-year-old housewife, came into the hospital July 17, 1929, with complaint of jaundice and itching of the skin. Ten months before admission the patient gave birth to a normal child. Two weeks later she was seized with severe pain across the upper abdomen, associated with indigestion but not jaundice. During the next four months she was troubled with recurring attacks of severe pain centering in the right hypochondrium. Following an attack six months before admission to this hospital she had cholecystectomy and appendectomy performed in another hospital. During the fourth week of her convalescence she became jaundiced, her stools became clay colored, her urine deep brown; pruritus set in and was soon quite distressing. Three months after her first operation, and three months before admission to this hospital, the patient underwent a second operation in the same hospital. At operation the right sub-hepatic region was found to be a mass of adhesions and it was considered impossible to perform any remedial operation. During convalescence there were repeated hæmorrhages into the wound despite blood transfusion. The jaundice continued until admission to this hospital, six months after the original operation, and the patient steadily lost weight and strength.

On admission to this hospital the patient was a thin, deeply jaundiced, enfeebled woman. At examination there was diffuse resistance in the upper abdomen, especially on the right, but no tenderness. A thin sero-purulent discharge oozed from an unhealed area in a right paramedian epigastric scar. The spleen was easily palpable, and although the liver seemed enlarged, no definite edge could be felt. The patient's evening temperature was 101° F. by mouth, her pulse rate 130. The leucocyte count was slightly elevated, there was a marked reduction in the hæmoglobin and erythrocyte count; the stools were gray and tests for bile were negative; the urine contained much bile. The liver function test showed a bilirubin level of 21.4 milligrams per 100 cubic centimetres

of blood. The sedimentation rate was increased; the clotting time was fifteen to thirty minutes; the bleeding time was normal.

July 29, 1929, operation was performed by Dr. Beth Vincent. Extensive dense adhesions bound together the under surface of the liver and the colon, stomach and duodenum. The common duct was obliterated, making impossible direct anastomosis between biliary tract and stomach or duodenum. The dilated stump of the hepatic duct was drained by suturing a catheter into it in order to establish an external biliary fistula for transplantation later. Blood transfusion was performed immediately afterwards. Convalescence was satisfactory, bile drainage through the catheter was free, and the jaundice gradually subsided, until on discharge four weeks after operation the scleræ were only faintly tinged. The patient was sent to a convalescent home until the fistulous tract should become well formed.

November 1, 1929, the patient, greatly improved, was re-admitted to the hospital. She was free from jaundice, she had gained weight, and she had not showed abnormal bleeding. Only 12 per cent. of the bromphthalein was retained in the liver function test; the icteric index was 10, the bleeding time three minutes, the clotting time twelve minutes.

November 6, fifteen weeks after the drainage operation, Doctor Vincent performed the second stage of the restorative procedure, the cutaneous end of the biliary fistula being cored out and freed up sufficiently to allow it to be sewed into the first portion of the duodenum. The operation was preceded by blood transfusion. On the second day after operation hæmorrhage into the wound occurred, and the wound edges parted to allow bile-stained fluid to escape. By the fifth day an external duodenal fistula communicating with the wound was well established. Fluids taken by mouth (including dyes) rapidly appeared at the wound, the skin became excoriated about the wound, and the patient began to grow weaker. One week after the transplantation procedure jejunostomy was performed under local anæsthesia. The operation was preceded and followed by blood transfusions. Gravity feeding was immediately instituted, as described above, making use of the following regimen:

- (1) Sips of water.
- (2) Normal salt solution, 180 cubic centimetres every hour into gravity tank.
- (3) "High caloric mixture" (cream, lactose, egg) 60 cubic centimetres every two hours into tank.
- (4) Sweetened orange juice, 540 cubic centimetres three times a day into tank.
- (5) Broths and gruels, 540 cubic centimetres three times a day into tank.
- (6) Milk, 540 cubic centimetres three times a day into tank.

In addition, the discharges from the fistula were collected by constant suction and were fed into the jejunum through the reservoir. In this way the patient took daily and without any discomfort over 11 litres (330 ounces) of water, salt, food and fluid recovered from the fistula; the total value was over 3,000 calories. The patient slept much of the time while being fed in this way. No further hæmorrhage from the wound or elsewhere occurred, the discharge from the fistula diminished in amount, and four weeks after operation the fistula had closed entirely. The bleeding and clotting time, prolonged after development of the external duodenal fistula, became normal with return of secretions to the jejunum and improvement in the patient's general condition. The jejunostomy tube was removed at the end of four weeks. On discharge from the hospital seven weeks after transplantation of the biliary fistula into the duodenum the patient's wounds were healed, she was eating with relish, the stools were brown and she was perfectly comfortable. The jaundice had disappeared.

It seems certain that the hyper-feeding by jejunostomy and the restoration to the upper intestine of essential secretions contributed largely to the successful outcome in this case.

GRAVITY FEEDING BY JEJUNOSTOMY

Subsequent events show that this case falls into the group of partial successes following transplantation of external biliary fistula into the upper duodenum or stomach. The patient has been troubled with recurring attacks of upper abdominal pain, fever, and obstructive jaundice lasting two to five days, and accompanied by increase in the size of the liver. At a third operation the transplanted fistulous tract was dilated and a rubber tube was sutured into it, the tube to be discharged through the duodenum later. Whether this procedure will give the patient adequate biliary drainage remains to be seen.

The author wishes to thank Dr. Beth Vincent for permission to report this case.

BIBLIOGRAPHY

- ¹ Kelling, G.: *Centralblatt für chir.*, vol. xlix, p. 779, 1922.
- ² Mayo-Robson, A. W.: *Brit. Med. Jour.*, vol. i, p. 1, January 6, 1912.
- ³ Davis, Lincoln: *N. E. Jour. Med.*, vol. cc, p. 313, 1929.
- ⁴ Erdman, S.: *ANNALS OF SURGERY*, vol. lxxiii, p. 793, 1921.
- ⁵ Colp, R.: *ANNALS OF SURGERY*, vol. lxxviii, p. 725, 1923.
- ⁶ Walters, W.: *J. A. M. A.*, vol. lxix, p. 1847, 1927.
- ⁷ Van Lennep: *The Hahnemannian Monthly*, vol. xlviii, p. 1, 1914.
- ⁸ Mayo, W. J.: *Am. Jour. Med. Sci.*, vol. cxliii, p. 469, 1912.
- ⁹ Alvarez, W. C.: *J. A. M. A.*, vol. lxix, p. 2018, 1917.
- ¹⁰ Scott, H. G., and Ivy, A. C.: *ANNALS OF SURGERY*, vol. xciii, p. 1197, 1931.

PERFORATED PEPTIC ULCER OF MECKEL'S DIVERTICULUM*

BY ROGER T. VAUGHAN, M.D., AND HARRY A. SINGER, M.D.

OF CHICAGO, ILLINOIS

FROM THE SURGICAL DIVISION OF THE COOK COUNTY HOSPITAL AND THE UNIVERSITY OF ILLINOIS COLLEGE OF MEDICINE

MECKEL'S diverticulum, the persistent remains of the omphalo-mesenteric duct, occurs in approximately 1 to 2 per cent. of the human race. The wall of the diverticulum is generally of small-intestine type but may at times contain structures normally located in other parts of the digestive tract. Elements of gastric, duodenal and colonic character, also glandular tissue of pancreatic and questionable origin have been described within the walls of the diverticulum. Of these heterotopic structures, gastric mucosa is of greatest clinical importance since its secretion here as in the stomach has the ability to digest the intestinal mucosa and muscularis and lead to the formation of peptic ulcer. Mucous membrane of the gastric type is found according to Koch¹⁵ in 12 per cent. and according to Schaetz²⁵ in 16.6 per cent. of Meckel's diverticula. As with peptic ulcers of the stomach and duodenum, those of Meckel's diverticulum are subject to hæmorrhage and acute perforation. The occurrence of a silent melæna as an indication of a bleeding ulcer of Meckel's diverticulum has been frequently stressed particularly by the pediatricians. Perforative peritonitis from ruptured ulcer of Meckel's diverticulum is equally as important as hæmorrhage but has not been accorded a commensurate degree of attention in medical literature.

The first demonstration of the relationship between perforation of a Meckel's diverticulum and peptic ulcer was by Hübschmann.¹² He reports the case of a boy of four and one-half years, who, twenty-four hours after a fall in which the abdomen was struck, began to suffer from repeated intestinal hæmorrhages. About four weeks after the onset of the illness signs of peritonitis appeared. Laparotomy was performed and the patient died shortly afterwards. At the post-mortem, the peritonitis was found to be due to perforation of a Meckel's diverticulum grossly gastric in structure. Hübschmann was able to demonstrate microscopically that almost the entire diverticulum was lined by fundus glands and that the perforation was located in intestinal portion just beyond the junction of the two types of mucous membrane. He pointed out that no signs of inflammation were present and that therefore infection would not have been the cause of the perforation. Six years before the appearance of Hübschmann's article Deetz⁵ published the report of a boy of nine years who was successfully operated for a perforated Meckel's diverticulum. The diverticulum was amputated peripheral to the site of rupture precluding the possibility of determining the histologic appearance of the tissues about the perforation itself. In the excised diverticulum, pancreatic tissue and gastric mucous membrane were found. In his closing paragraph Deetz suggests that in this form of diverticulitis the conditions which lead to perforation may be the same as in gastric ulcer.

There have been relatively few cases of perforated peptic ulcer of Meckel's diverticulum reported as such. Aside from Hübschmann's case

* Read before the Chicago Surgical Society, February 6, 1931.

ULCER MECKEL'S DIVERTICULUM

in which trauma was considered to have played some part and Deetz's case in which the region of the ulcer was not investigated microscopically, fourteen instances of perforated peptic ulcer of the diverticulum are recorded. Of these fourteen cases histologic examinations are lacking in four.

The first undisputed case of ruptured peptic ulcer of Meckel's diverticulum was published in 1915 by Gramen⁸ who described in the diverticulum a lesion which possessed gross and microscopic characteristics of a perforated peptic ulcer. As in Hübschmann's case the lesion was located on the intestinal side of the junction between gastric and small-bowel types of mucosa. Four years later Müller²² related having observed a recent perforation of a punched-out, calloused ulcer which was treated by simple suture of the hole. A second operation was performed after recovery from the first and at this time the diverticulum was excised. In the region of the previous perforation histologic examination showed both intestinal and gastric types of mucous membrane. In 1924 Brasser⁴ published a typical case with the gastric mucosa of Meckel's in a state of chronic catarrh. The ulcer was found in the typical location, *i.e.*, on the intestinal side of the union between the two types of mucosa. In the same year a comprehensive survey of the subject, which included a detailed description of a case was published by Humbert.¹³ The following year (1925), Ulrich³⁰ furnished another instance of perforated ulcer of Meckel's diverticulum due to the digestive action of the secretion from heterotopic gastric glands.

During 1926 reports of five cases were added. Stulz and Woring²⁸ recorded two instances of perforation of Meckel's diverticulum due to lesions which grossly resembled peptic ulcer. However, a microscopic examination of neither specimen was made. Two additional cases were described by Kleinschmidt¹⁴ who showed in his first case the presence microscopically of gastric mucous membrane in the diverticulum but was unable to examine the region of the ulcer which was destroyed by surgical clamps. The specimen obtained at operation in Kleinschmidt's second case of perforated diverticulum was lost before material for histology was excised. The fifth case published in 1926 was briefly mentioned by Neff²³ in a discussion of the paper by Abt and Strauss.¹ No gross or microscopic description of the lesion was given at this time. McCalla¹⁸ in 1927 described a case of perforated ulcer situated at the junction of the ileum and a Meckel's pouch. The entire diverticulum was found microscopically to be lined by gastric mucous membrane. In the following year Hartglass¹⁰ published the facts in connection with a recent perforation of a chronic ulcer located also at the base of a Meckel's diverticulum. Histologic examination showed the ulcer in the typical location with reference to the intestinal and gastric types of glands. The most recent report listed is that of Fèvre, Patel and Lepart.⁷ These authors report two cases both with gross characteristics of peptic ulcer but with gastric mucous membrane in the lining of only one and duodenal mucosa in the other.

The number of perforations of Meckel's diverticulum due to peptic ulcer listed above in all probability does not even approximate the total number of cases that have actually occurred. Aside from those cases which are observed and not recorded there is a considerable number published as instances of diverticulitis with perforation. Particularly does this apply to the cases reported prior to Hübschmann's discovery. Earlier treatises on diseases of Meckel's diverticulum (see Denecke,⁶ Hilgenreiner,¹¹ Turner,²⁹ Meyer²¹ and Wellington³²) contain a considerable number of perforations ascribed to various non-chemical causes. It is quite probable judging from the present high incidence of peptic ulcer as compared with other etiologic

factors of perforation that in a fair proportion of the cases contained in these compilations, the actual cause of the perforation, *i.e.*, the peptic ulcer, was overlooked. Especially is this likely to be true of those cases of so-called spontaneous perforation where a demonstrable cause such as a foreign body is absent. For instance, in the case of L  wen¹⁶ reported in 1909 the presence at operation of a spurting blood-vessel on the edge of the perforation is highly suggestive of the presence of an ulcer rather than of a phlegmonous diverticulitis in which category the lesion is classified. In case one of Meyer, that of a woman of seventy with a ruptured Meckel's diverticulum, the description of the lesion seems indicative of a perforated peptic ulcer. The gross and microscopic characteristics of the diverticulum point strongly to the presence of two distinct types of mucosa, the one manifestly intestinal, the other probably gastric. This lack of recognition of peptic ulcer as the cause of symptoms arising from lesions of Meckel's diverticulum can also be detected in reports subsequent to H  bschmann's publication. For instance, Mayo and Johnson¹⁷ in 1926 recorded a case of bleeding from Meckel's diverticulum and ascribed the h  morrhage to trauma to the polypoid or inflamed diverticular mucosa. Curiously enough the accompanying photomicrograph of the diverticulum, intended to demonstrate the polypoid overgrowth, exhibits typical gastric glands, the presence of which apparently was overlooked.

In addition to the perforations of Meckel's diverticulum recognized as resulting from peptic ulcer and those in which a peptic ulcer was probably overlooked, there is a third group in which an ulcer is present but is not suspected of actual perforation. This last group comprises cases in which there is found a typical penetrating ulcer extending through the entire thickness of the diverticulum having a base formed by an adjacent structure. The histories in a number of these cases suggest that they are examples of actual free perforation with subsequent spontaneous plugging of the hole. The antecedent occurrence of acute severe abdominal pain followed by the other manifestations of a diffuse peritonitis can hardly be explained on the basis of mere penetration. It is necessary in such an instance to infer actual perforation with leakage. The *modus operandi* is as follows: Within a relatively short period following rupture, a neighboring loop of bowel, portion of omentum or mesentery or merely a plaque of fibrin, becomes agglutinated to the site of perforation and the escape of intestinal content is thereby checked. The processes involved are very similar to those described in connection with spontaneous closure of perforated gastroduodenal ulcer (see Singer and Vaughan²⁷) except that conditions for walling-off are not as favorable in the upper as in the lower abdomen.

The mechanism of spontaneous sealing is illustrated in two of the cases listed in the group of perforations reported as such. In Gramen's patient at the time operation was performed the pea-sized perforation which had led to a more or less diffuse peritonitis was effectively covered by a tag of omentum. At the autopsy of McCalla's patient who died of diffuse peri-

tonitis, the base of the ulcer was found adherent to the anterior abdominal wall. It was apparent to the pathologist that the free perforation was of longer standing than the adhesions and that rupture had occurred some time prior. The case of peptic ulcer of Meckel's diverticulum reported by Meulengracht²⁰ as penetrating, in which the base was covered by a fold of mesentery, may rather have been an old sealed perforation. The lesion described by Guibal,⁹ an excavation which extended beyond the walls of the diverticulum and which formed a pocket in the mesentery of the ileum, may have resulted from a previous perforation with attendant adhesions. The case reported by Peterman and Seeger²⁴ as a Meckel's diverticulum with hæmorrhage very likely was one of spontaneous closure of a perforation. The patient, a child of eight, had a history of previous attacks of melæna and one attack of intra-abdominal hæmorrhage following slight

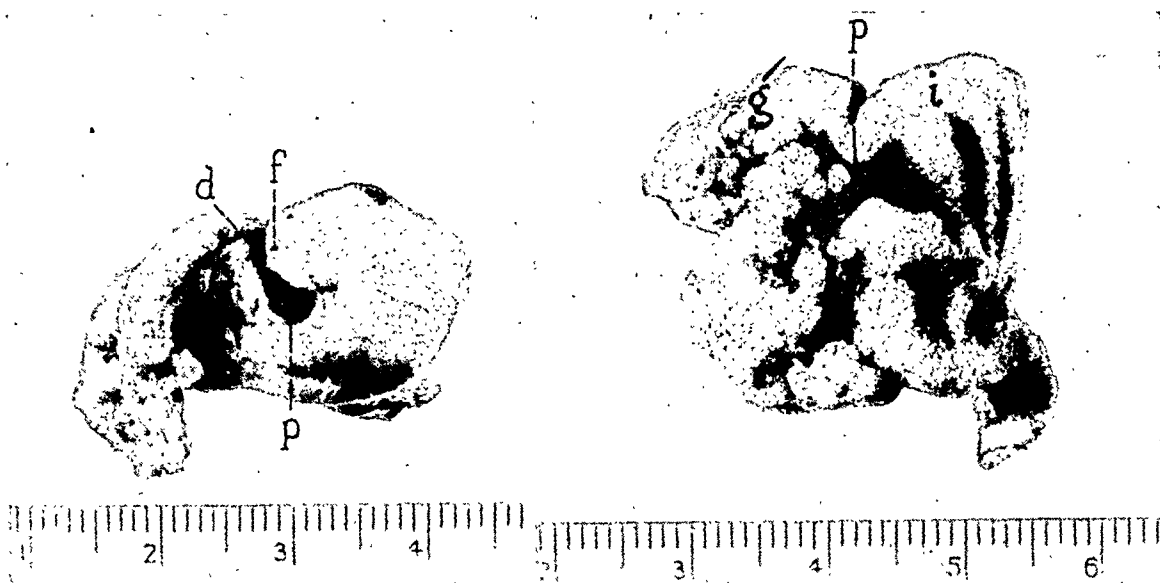


FIG. 1.

FIG. 2.

FIG. 1.—External appearance of perforated peptic ulcer of Meckel's diverticulum. The perforation (p) is just proximal to the bulbous tip. A plaque of fibrin (f) torn in separating the diverticulum from the bladder presents a defect (d) which in the photograph simulates a lateral extension of the perforation.

FIG. 2.—Opened Meckel's diverticulum fixed in formalin and shrunk thereby. The lining of the proximal three-fifths comprised of intestinal mucosa (i) is thrown into folds (valvulae conniventes) and curled upon itself. The lining of the distal two-fifths which represents gastric mucosa (g) is thick, coarse, and devoid of true folds. The perforation (p) is located on the intestinal side of the junction of the two types of mucous membrane.

trauma. At the operation performed for the hæmoperitoneum, the source of bleeding was not sought. At a subsequent operation an ulcer of Meckel's diverticulum was found, the base of which was formed by the ileum. It is quite likely that the hæmoperitoneum encountered during the course of the first operation resulted from an ulcer which bled and perforated almost simultaneously. The first case of Aschner and Karelitz² listed by them as one of penetrating ulcer, presented at the primary operation evidences of recent peritoneal and diverticular inflammation including extensive enlargement of the mesenteric lymph-nodes. A palliative ileostomy was performed. Following recession of the signs of inflammation, a second operation was undertaken thirteen days after the first. A Meckel's diverticulum was

found adherent to the undersurface of the mesentery and in separating the two a hole was exposed which proved to be a peptic ulcer located in the ileum just proximal to the neck of the pouch. A massive granuloma in the first case of Meckel's diverticulum reported by Abt and Strauss may have originated in a perforated ulcer by a process similar to that in which a ruptured appendix leads to a chronic inflammatory tumor (pyogenic granuloma). The case reported below furnishes a further example of perforated peptic ulcer of Meckel's diverticulum with spontaneous closure of the hole. However, the sealing which was due to fibrinous adhesions was much more recent in this than in any of the aforementioned cases.

CASE REPORT.—J. S., a white boy of seven, was admitted to the Cook County Hospital, December 29, 1931, at 11:30 P.M., with the presenting complaint of lower abdominal pain. The illness which was described by the mother and child conjointly,

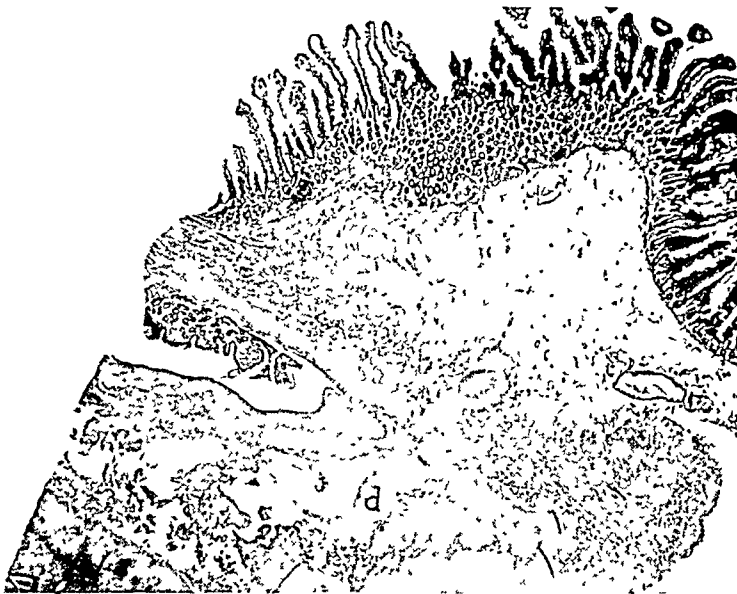


FIG. 3.—Peptic ulcer of Meckel's diverticulum cut tangentially through the site of perforation which is occupied by a mass of fibrin and debris (d). The lining glands are of the intestinal type and contain numerous goblet cells.

began December 28, 1930, at 1 P.M., when intermittent pain only moderately sharp was felt in the right lower quadrant. The patient was put to bed and a cathartic administered. The pain continued interruptedly until 3 P.M., when the boy fell asleep and awakened an hour later without pain. At 5:30 P.M. he ate his meal following which the pain recurred. It was noted at this time that movements of the right lower extremity or attempts to bear weight upon it resulted in an aggravation of the pain. Throughout that evening and night and the following day (December 29, 1930) a dull pain appeared at intervals until 6 P.M., when it reached its acme and became continuous. At this time any movement resulted in intense pain. An inventory of symptoms by systems yielded no pertinent information. The past history was essentially negative. There had been no similar attacks previously and no signs of melæna at any time.

The countenance of the child indicated that he was acutely ill and suffering pain. The temperature upon admission was 101° F., the pulse and respiratory rates 120 and 28 respectively. The essential physical observations consisted of tenderness and rigidity localized to the right lower abdominal quadrant. Peristaltic sounds were normally

audible. The white blood count was 16,400. The diagnosis of acute appendicitis was made and laparotomy advised. At operation the appendix was found to be normal although there was a localized fibrinous peritonitis in the right lower quadrant. Exploration disclosed at the usual site of origin a Meckel's diverticulum which was attached by fibrinous adhesions to the right side of the superior surface of the bladder. Slight tension led to separation of the adhesions and exposure of a perforation in the distal half of the diverticulum. The latter was removed by clamp and ligature at the base and purse-string inversion. The recovery was uneventful and the patient was discharged January 9, 1931.

Surgical Report.—The diverticulum (Fig. 1) measured 4 centimeters in length and had a circumference at its base of 3 centimeters. The distal two-fifths of the specimen was somewhat bulbous. The entire serosa was injected and dull. Just proximal to the bulbous tip was a perforation (p) 2-3 millimeters in diameter. About the perforation was a thick plaque of fibrin (f) which exhibited a defect (d) presumably the result of a tear. The opened diverticulum (Fig. 2) presented two different types of lining. In the proximal three-fifths (i) the mucous membrane resembled that of the ileum, being thin and thrown into regular, fine folds on the order of valvulae con-

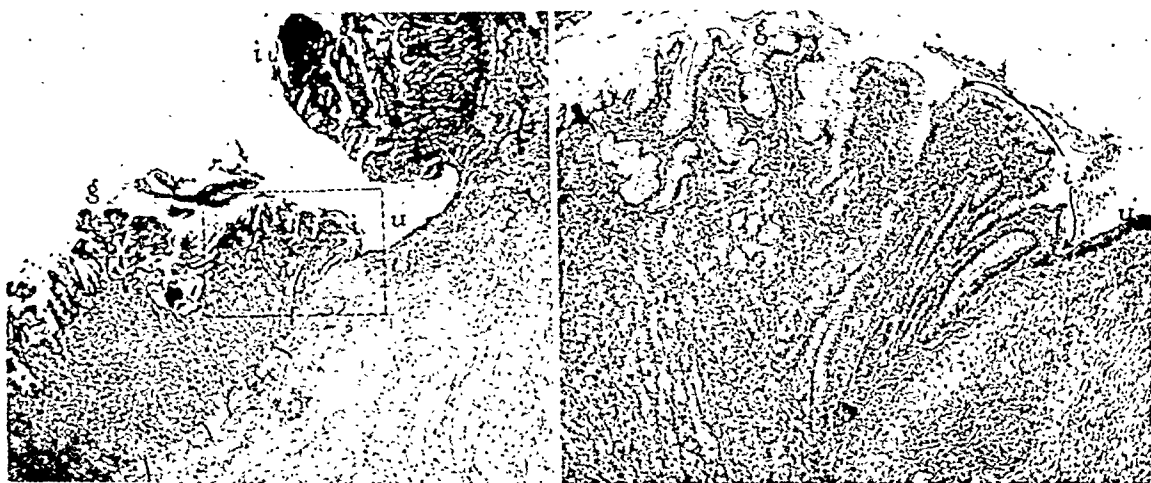


FIG. 4.

FIG. 5.

FIG. 4.—Photomicrograph of a portion of the ulcer beyond the point of perforation. Both proximal and distal borders of the ulcer are covered by mucosa of the intestinal type (i). A sudden transition from the intestinal to the gastric type of mucous membrane (g) occurs just beyond the distal margin of the ulcer (u) which is covered by a single layer of epithelium.

FIG. 5.—Higher magnification of the transitional zone within the rectangle indicated in Fig. 4. The gastric glands (g) are of the fundus type and the intestinal glands (i) are of the small bowel type. The epithelium covering the floor of the ulcer (u) is columnar.

niventes. The lining of the distal two-fifths (g) which had the appearance of gastric mucous membrane was so thick as to form a tumor-like swelling which almost filled the lumen of the terminal portion. A plug of mucus occupied the narrow lumen of this part of the diverticulum although no actual constriction separated the two types of mucous membrane. Upon close inspection, minute openings representing presumably the mouths of the gastric pits could be discerned. On the intestinal side of the junction of the two kinds of lining was a round defect (p) 4 millimeters in diameter which extended through the entire thickness of the wall and presented the usual characteristics of an acute perforation of a chronic peptic ulcer.

Microscopic Description.—In histologic sections of the proximal portion of the diverticulum the typical appearance of the intestinal wall is noted. (See Fig. 3.) In sections of the distal portion the microscopic picture is that of the stomach wall (see Fig. 5), the glands of the mucosa being of the fundus type, with numerous parietal cells. Preparations taken to include the region of the ulcer (Fig. 4) shows intestinal mucosa at both the proximal and distal borders, the latter passing over abruptly into

the gastric type. The margin of the ulcer in the region of the perforation exhibits the usual changes seen in similar lesions located in the stomach or duodenum. The edge consists of a cellular débris beneath which are successive layers of fibrinoid necrosis, young granulations and scar tissue. One margin of the ulcer shows evidences of healing, the floor of the defect (Figs. 4 and 5) being covered by a single layer of columnar epithelium. The muscular coats of the diverticulum correspond in type to those of the overlying mucous membrane. The intestinal portion possesses two well-defined layers, an inner circular and an outer longitudinal, whereas the gastric part exhibits smooth muscle bundles running in various directions without apparent division into layers.

Symptomatology.—Symptoms referable to the diverticular ulcer prior to perforation are, with the exception of hæmorrhage, seldom noted. The post-prandial distress of a rhythmic nature, so characteristic of peptic ulcer of the upper gastro-intestinal tract is only occasionally mentioned. Megévaud and Dunant's¹⁹ patient, who was twenty-eight years of age, in one period of his illness in addition to hæmorrhages, suffered from abdominal pain which appeared before meals and was relieved by food. In the case reported by Kleinschmidt, a boy of fifteen experienced for a year prior to perforation a rhythmic distress which was located in the right lower quadrant and occurred one and one-half hours after meals. In the remaining cases no mention is made of symptoms resembling simple ulcer distress. The fact that most of the individuals are too young to give trustworthy information may account in part for the infrequency of history of previous ulcer complaints. Melæna, in contrast to post-prandial distress, is seldom absent in the history. The frequency of intestinal hæmorrhage has been emphasized repeatedly, particularly by the pediatricians. The statement, however, that melæna occurs in all cases in which gastric mucosa is found in Meckel's diverticulum (Barney³) is not borne out by the facts. Our own patient for instance had never suffered from intestinal hæmorrhage of sufficient grade to attract the mother's attention or to lead to signs of anæmia. The patient of Hartglass, a girl of fourteen, likewise gave no history of melæna. These hæmorrhages are frequently profuse and may be repeated at varying intervals, as in the cases of Humbert, Kleinschmidt, Stultz and Woring (Case II) and McCalla. At times melæna immediately precedes the perforation as reported by Brasser and as likely occurred in the case of Aschner and Karelitz. Other symptoms such as abdominal cramps which may be attributable to the diverticulum rather than the ulcer are at times in the antecedent history.

The symptoms of perforation of peptic ulcer of Meckel's diverticulum apparently do not parallel those of perforated gastroduodenal ulcer in a large percentage of the cases. However, according to published reports in a few cases, the onset is sudden and violent, and evidences of a perforative peritonitis develop within less time than might be expected with a phlegmonous diverticulitis for instance. In Kleinschmidt's first case the onset was very sudden and at the initial examination made within less than three hours after the occurrence of pain, diffuse rigidity and tenderness were already noted. In his second case the pain of onset was likewise intense. The clinical ac-

count given by Hartglass in which the patient was seized suddenly by a violent abdominal pain followed rapidly by the symptoms and signs of a diffuse peritonitis was like gastroduodenal perforation. In the first case of Fèvre, Patel, and Lepart there was likewise sudden onset of intense pain and the development of a diffuse peritonitis in less than twenty-four hours. It is not unlikely that the symptoms in a number of other cases were similar to those of acute perforation of gastroduodenal ulcer but that a careful inquiry was not or could not be made. Nevertheless, in a fair percentage of the cases, the onset is gradual and the peritonitis remains local. In our own case even after discovery of the perforation in the diverticulum, we failed in retrospect to obtain any history of intense or sudden pain or of symptoms of an initial widespread peritonitis.

The absence of an abrupt onset and the lack of development of a diffuse peritonitis in so many of the cases are explained by the limited quantity of leakage of a relatively non-irritating fluid. In most instances the escape of intestinal content is checked by the formation of adhesions. This is favored by the presence of adjacent intestinal loops and the overlying mesentery which move synchronously with the diverticulum. Occasionally the character of the content of the diverticulum may be the effective factor in preventing profuse leakage. In the case of Guibal a plug of thick mucus occupied the perforated portion of the diverticulum and occluded the hole. In the case herein reported a similar condition was encountered.

Diagnosis.—Prior to Hübschmann's demonstration of the relationship of perforation of Meckel's diverticulum to peptic ulcer the pathogenetic processes involved were considered to be identical with those of perforative appendicitis. The clinical distinction it was assumed could hardly be made. The knowledge that *the primary lesion is not a phlegmonous diverticulitis* but rather a peptic ulcer should help in the pre-operative recognition of a certain percentage of perforations of Meckel's diverticulum. Of most importance in the antecedent history is the occurrence particularly in children and especially boys, of melæna which generally constitutes the only manifestation of the unruptured ulcer. A story of post-prandial distress is generally lacking. The co-existence of a gastroduodenal ulcer and a similar lesion of Meckel's diverticulum as reported by Schreuder²⁶ is most exceptional and for practical purposes may be disregarded. The occurrence of sudden, violent pain beginning generally in the lower half of the abdomen followed almost immediately by the symptoms and signs of a diffuse peritonitis is characteristic of a perforated ulcer. When the patient is a child, the likelihood is still greater that the ulcer is located in a Meckel's diverticulum. The above peritonitis picture is hardly compatible with acute inflammation of the appendix which usually does not rupture until symptoms have persisted for twenty-four hours or so. The presence of free air in the peritoneal cavity which was noted at operation by Humbert constitutes a valuable Röntgen aid in the diagnosis of perforated gastroduodenal ulcer (Vaughan and Singer³¹). It is not to be expected early in cases of ruptured ulcer of

Meckel's diverticulum. The small bowel normally contains no appreciable amount of gas and only after ileus supervenes will air be available for escape through the perforation.

NOTE.—Since the above article was submitted for publication an additional report dealing with the subject has appeared in print (Cobb, D. B.: Perforated Peptic Ulcer of Meckel's Diverticulum. *ANNALS OF SURGERY*, vol. xciv, pp. 256-262, 1931). The observations recorded by Cobb illustrate a number of the points discussed in this paper including the tendency to spontaneous sealing of the perforation.

REFERENCES

- ¹ Abt, J. A., and Strauss, A. A.: Meckel's Diverticulum as a Cause of Intestinal Hæmorrhage. *J. A. M. A.*, vol. lxxxvii, pp. 991-996, 1926.
- ² Aschner, P. W., and Karelitz, S.: Peptic Ulcer of Meckel's Diverticulum. *ANNALS OF SURGERY*, vol. xci, pp. 573-582, 1930.
- ³ Barney, L. F.: Meckel's Diverticulum. *J. Kansas M. Soc.*, vol. xxvii, pp. 166-170, 1927.
- ⁴ Brasser, A.: Ulcus pepticum perforans des Meckel'schen Divertikels. *Zentralbl. f. Chir.*, vol. li, pp. 2423-2427, 1924.
- ⁵ Deetz, E.: Perforationsperitonitis von einem Darmdivertikel mit Magenschleimhautbau ausgehend. *Deutsche Ztschr. f. Chir.*, vol. lxxxviii, pp. 482-493, 1907.
- ⁶ Denecke: Ueber die Entzündung des Meckel'schen Divertikels und die Gangrän desselben. *Deutsche Ztschr. f. Chir.*, vol. lxii, pp. 523-547, 1902.
- ⁷ Fèvre, M., Patel, and Lepart: Ulcères perforés du diverticule de Meckel. *Bull. et mém. Soc. nat. de chir.*, vol. lvi, pp. 756-767, 1930.
- ⁸ Gramen, K.: Ein Fall von chronischem Ulcus in einen Meckel'sschen Divertikel mit Perforation und diffuser Peritonitis. *Nordisches med. Archiv.*, vol. xlviii, Abt. 1, Chir., Haft 3-4, Nr. 9, pp. 1-17, 1915.
- ⁹ Guibal, L.: Ulcère peptique d'un diverticule de Meckel provoquant des hemorrhagies intestinales profuses. Opération. Guérison. *Bull. et mém. Soc. nat. de chir.*, vol. i, pp. 349-355, 1924.
- ¹⁰ Hartglass: Perforation d'un ulcère peptique siégeant sur un diverticule de Meckel. Opération. Guérison. *Bull. et mém. Soc. nat. de chir.*, vol. liv, pp. 1091-1094, 1928.
- ¹¹ Hilgenreiner, H.: Entzündung and Gangrän des Meckel'schen Divertikels. *Beitr. zur klin. Chir.*, vol. xl, pp. 99-135, 1903.
- ¹² Hübschmann: Spätperforation eines Meckel'schen Divertikels. *München med. Wchnschr.*, vol. lx, pp. 2051-2053, 1913.
- ¹³ Humbert, J.: L'ulcère peptique du diverticule de Meckel. Thèse, Paris, vol. xx, (No. 395), pp. 1-108, A. Legrand, editeur, 1924.
- ¹⁴ Kleinschmidt, K.: Das Ulcus pepticum des Meckel'schen Divertikels. *Beitr. z. klin. Chir.*, vol. cxxxviii, pp. 715-720, 1926.
- ¹⁵ Koch, M.: Naturforscherversammlung in Münster, 1912. Quoted by Hübschmann.¹²
- ¹⁶ Läwen: Perforiertes Meckelsches Divertikel. *München med. Wchnschr.*, vol. lvi, pp. 478-479, 1909.
- ¹⁷ Mayo, W. J., and Johnson, A. C.: Meckel's Diverticulum. *S. Clin. North America*, vol. vi, (No. 5), pp. 1127-1130, 1926.
- ¹⁸ McCalla, A. J.: A Case of Perforated Peptic Ulcer of Meckel's Diverticulum. *Canad. M. A. J.*, vol. xvii, pp. 79-81, 1927.
- ¹⁹ Mégevaud, E. C., and Dunant, R.: Ulcère peptique du diverticule de Meckel. Hemorrhagies intestinales. *Rev. de chir.*, vol. lx, pp. 536-552, 1922.
- ²⁰ Meulengracht, E.: Ein teilweise mit Magenschleimhaut bekleidetes und den Sitz eines Ulcus pepticum bildendes Meckelsches Divertikel. *Virchows Arch. f. path. Anat.*, vol. ccxxv, pp. 125-128, 1918.

- ²¹ Meyer, A.: Beitrag zur Kenntnis der Entzündung des Meckel'schen Divertikels. Deutsche Ztschr. f. Chir., vol. cxiii, pp. 346-366, 1912.
- ²² Müller, P.: Ueber das Ulcus pepticum (perforans) des persistierenden Dottergangs (Meckel'schen Divertikels) und seine Verwandtschaft mit dem Ulcus ventriculi. Beitr. z. klin. Chir., vol. cxv, pp. 560-577, 1919.
- ²³ Neff, F. C.: Discussion to Abt and Strauss,¹ p. 995.
- ²⁴ Peterman, M. G., and Seeger, S. J.: Meckel's Diverticulum with Hemorrhage. Am. J. Dis. Child., vol. xxxvi, pp. 515-522, 1928.
- ²⁵ Schaetz, G.: Beiträge zur Morphologie des Meckel'schen Divertikels (Ortsfremde Epithelformationen im Meckel). Beitr. z. path. Anat. u. z. allg. Path., vol. lxxiv, pp. 115-293, 1925.
- ²⁶ Schreuder, O.: Ein seltener Fall von Darmblutung. Zentralorg. f. d. ges. Chir., vol. xxx, p. 490, 1925.
- ²⁷ Singer, H. A., and Vaughan, R. T.: The "Formes Frustes" Type of Perforated Peptic Ulcer. Surg. Gynec. and Obst., vol. I, pp. 10-16, 1930.
- ²⁸ Stulz, E., and Woringer, P.: Peptic Ulcer of Meckel's Diverticulum. ANNALS OF SURGERY, vol. lxxxiii, pp. 470-478, 1926.
- ²⁹ Turner, P.: Meckel's Diverticulum and Its Pathology. Guy's Hosp. Rep., vol. lx, pp. 279-321, 1906.
- ³⁰ Ulrich, G. R.: Et Tilfaeldi af Perforeret Meckel's Diverticulum. Ugesk. f. laeger., vol. lxxxvii, pp. 664-666, 1925.
- ³¹ Vaughan, R. T., and Singer, H. A.: The Value of Radiology in the Diagnosis of Perforated Peptic Ulcer. Surg. Gynec. and Obst., vol. xlix, pp. 593-599, 1929.
- ³² Wellington, J. R.: Meckel's Diverticulum with Report of Four Cases. Surg., Gynec. and Obst., vol. xvi, pp. 74-78, 1913.

BENIGN TUMORS OF THE STOMACH*

By G. PAUL LAROCQUE, M.D.

AND

E. LEE SHIFLETT, M.D.

OF RICHMOND, VIRGINIA

FROM THE DEPARTMENTS OF SURGERY AND ROENTGENOLOGY, RESPECTIVELY, MEDICAL COLLEGE OF VIRGINIA

THE caption, "Benign Tumors of the Stomach", is employed to direct attention to the occurrence of definite, non-malignant tumors and polypoid masses of hypertrophied mucosa of the stomach in individuals with the clinical history and Röntgen-ray findings of stomach disease.

The fact that approximately a thousand cases of benign tumors of the stomach have been observed within recent years would lead one to believe that the disease is not rare, and that we should have progressed past the stage of isolated case reports in the study of the disease. When it is remembered, however, that during the same period many thousands of cases of ulcer and cancer have been encountered, benign tumors must be looked upon as comparatively rare.

But not all the recorded cases of benign tumor of the stomach are reported in sufficient detail to give accurate means of diagnosis, or conclusions as to the best method of treatment; hence we have not yet been lifted out of the stage of case reports into the stage of organized knowledge of the subject.

The purpose of this report is, to put on record certain important details of the clinical and röntgenological study and operative treatment of a case of benign tumor of the stomach and to bring to attention certain studies from literature.

The case is one of massive vomiting of blood in a young man who showed, upon röntgenological examination, a definite ulcer on the stomach side of the pylorus and a pedunculated polypoid mass of greatly hypertrophied mucous membrane of the stomach prolapsing into the duodenum.

A colored man, twenty-three years old (Case No. 31-9156) was admitted to St. Philip's Hospital March 19, 1931, immediately after vomiting a large quantity of blood. He was in serious shock, had a temperature of 97, pulse 130, blood pressure 100/55 and was in a desperate general condition. His blood examination showed 18 per cent. hæmoglobin, 1,110,000 red cells. There was a history extending over fourteen months, of vague stomach distress, but the symptoms were not continuous, nor sufficiently definite to lead one directly to the stomach. He had a history of syphilis, and his blood Wassermann was strongly positive.

Two days after admission and for several days thereafter, his stools contained much blood. His hæmoglobin was 11 per cent., red cells 890,000. Frequent blood examinations were made, for a while daily and semi-daily, until on May 25 (ten weeks),

* Read before the Richmond Academy of Medicine, March 22, 1932.

BENIGN TUMORS OF STOMACH

his hæmoglobin was 62 per cent., the red cells 3,580,000, and there were the usually found elements indicating blood regeneration. The stomach contents showed free HCl of 14 and total acidity 28.

It seemed unwise to make an X-ray examination of the stomach until twelve days after admission, at which time it was found that he had a marked, constant deformity (filling defect) of the pylorus, with hyper-motility, rapid emptying of the stomach and other signs of gastric syphilis, and a tumor in the region of the pylorus, indistinguishable from carcinoma.

He was treated with the popular dietetic and medicinal remedies for secondary anæmia and syphilis. X-ray examinations were repeated April 16, April 29, and in

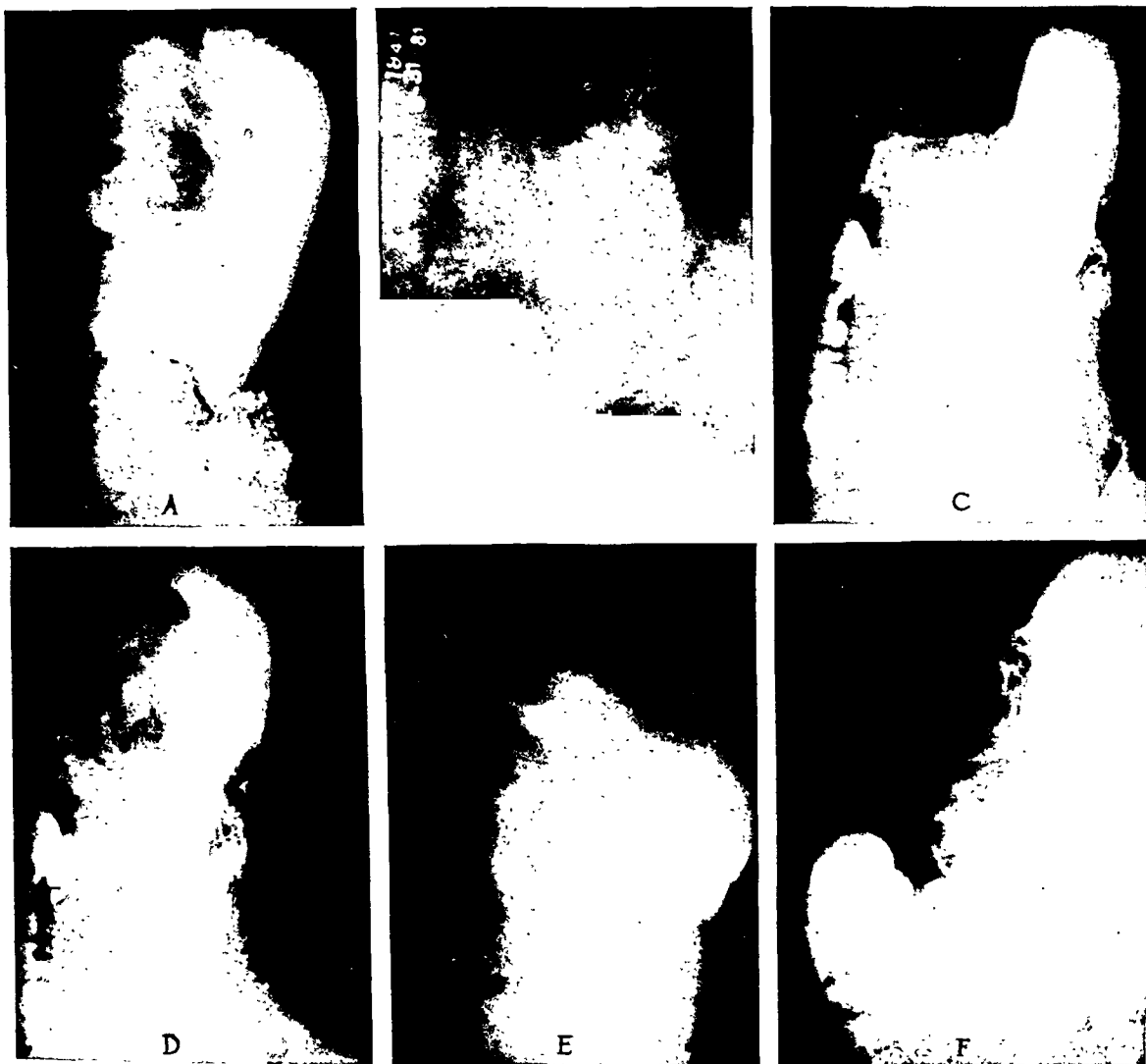


FIG. 1.—Röntgenograms of a case of hypertrophied mucous membrane of the stomach, pedunculated and prolapsing into the duodenum.

June, at which the same findings previously noted were present, though the filling defect in June in the region of the pylorus was about half the size noted at the first examination, March 31.

This patient remained in the hospital until May 28, at which time he seemed to be clinically well. His blood rapidly returned to normal, his appetite was good, digestion good, blood Wassermann reaction negative. He was referred to the dispensary for further treatment and observation.

He was readmitted to the hospital November 11, 1931, stating that for three days he had had epigastric pain partially relieved by food; some nausea and vomiting of blood the night before admission. He now looked well, his blood examination showed 95 per

cent. hæmoglobin, 5,150,000 red cells, his stools and gastric contents contained blood, blood Wassermann was negative.

The röntgenological report of November 12 is as follows: (E. Lee Shiflett) This report is made after a careful re-study of the films made at the time of his previous stay in the hospital and of those made in November, just before operation. Barium passes through the œsophagus and into the stomach without delay. The stomach fills readily and is normal in size and position. It is slightly atonic and peristalsis is quite sluggish. The pre-pyloric region presents an unusual appearance. In the upright position it fills smoothly with no defects. (Fig. 1 A.) In the prone position there are irregular filling defects which have the appearance of being produced by objects within the lumen, and not by induration of the stomach wall. At times the pylorus appears serrated (Fig. 1 B); again, the defects are multiple and seem to be surrounded by thin shells of barium which extend through the widened pyloric canal into the duodenum. (Fig. 1 C and D.) At other times the stomach is smooth to the pyloric ring, but in the antrum there is a single, central, irregularly circular translucency which is outlined by a thin line of the opaque mixture (Fig. 9 F), obscuring the duodenal cap. There is a large ulcer crater on the lesser curvature just proximal to the antrum. The duodenum is slightly dilated, and is never completely filled. Here, too, there are multiple oval to round central defects of a translucent nature, which seem to be due to objects within the duodenal lumen. At times the gastric and duodenal defects are definitely continuous. (Fig. 1 C, D, E.) The gastric and duodenal defects cannot be demonstrated in the erect position. (Fig. 1 A.) They are seen only with the patient prone. There is at no time any disturbance of the contour of the bulb. The second and third portions of the duodenum are normal.

Six-hour examination.—There is a gastric residue estimated at 10 to 15 per cent. The remainder of the meal shows normal advancement, and demonstrates no additional pathology.

Conclusion.—The findings are compatible with gastric syphilis with ulcer. There is hypertrophied gastric mucosa and a pedunculated tumor of the stomach which at times prolapses through the pyloric canal into the duodenum. There has been no appreciable change in the condition since the first examination, March, 1931, except the ulcer crater, which first made its appearance five months ago, is now further advanced and is penetrating. The general survey of the whole clinical situation was quite conclusive that this was not a malignant disease.

Operation was performed November 18, 1931. Through a transverse incision good exposure was secured. The stomach was normal in size; there were no adhesions. On the lesser curvature about two inches from the pylorus there could be felt an area of induration about the size of a silver half dollar, extending to the posterior wall of the stomach. With the stomach drawn up, a movable tumor could be felt just proximal to the pylorus extending through the pyloric ring into the duodenum. The tumor could be seen through the wall of the duodenum, and could be pushed back into the stomach and back into the duodenum at will. (Fig. 2.) It was realized at once that there was present a prolapsing tumor of the stomach.

The first three inches of duodenum was easily mobilized after dividing the outer layer of the peritoneum. The distal half of the stomach and the first inch of the duodenum were removed in one piece, and the ends of the stomach and duodenum united by the Haberer method.

The *pathological examination* was made by Dr. Lewis C. Pusch.

Gross Description.—A segment of pyloric portion of the stomach, 6 centimetres long, 10 centimetres in circumference at its upper extremity and 3 centimetres in diameter at its lower extremity. (Fig. 3.) There are two ulcers, 3 and 3½ centimetres long, which extend to distal plane of excision, but which are bordered proximally by hypertrophic mucosa which overhangs smooth bases. The ulcers are irregular in shape, each 1½ centimetres in greatest width, and separated by a polypoid mass of hypertrophic

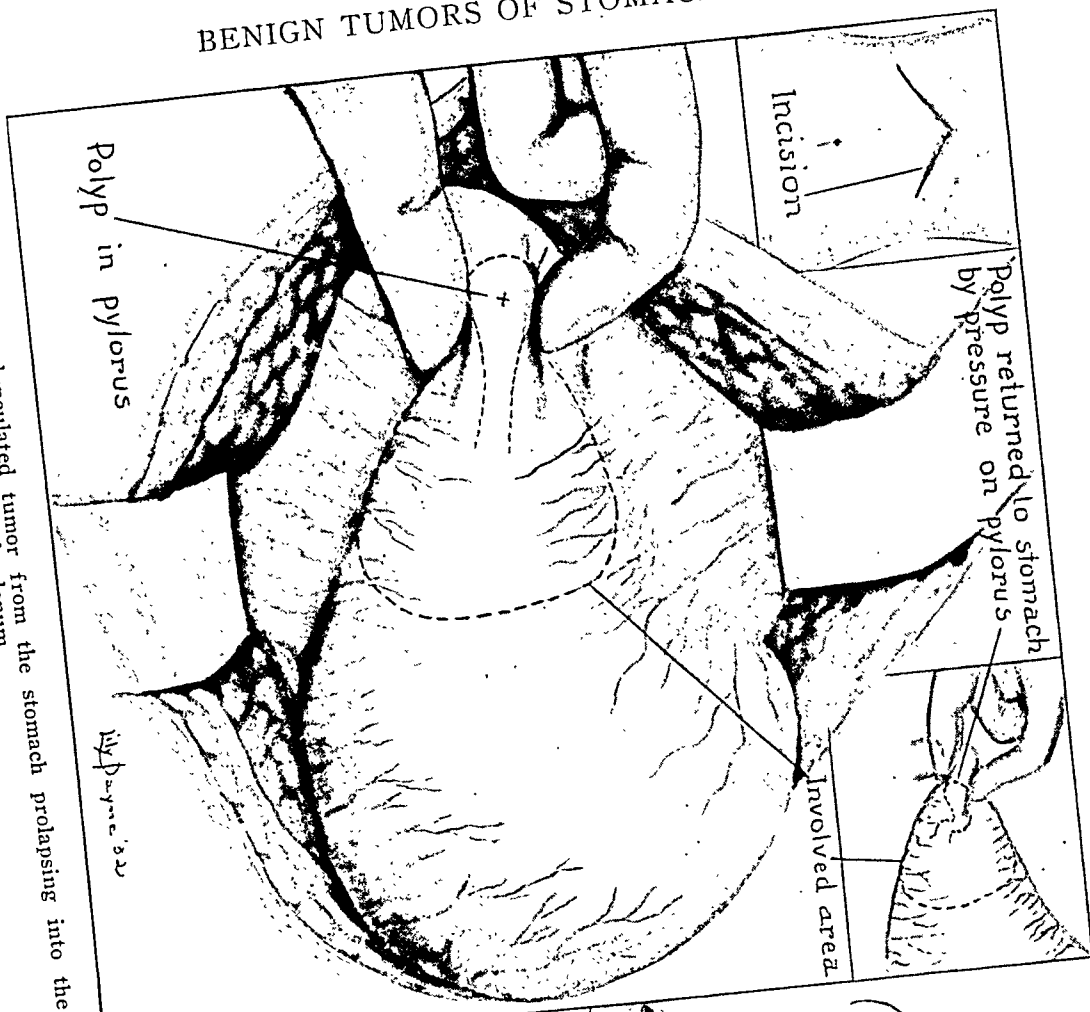


FIG. 2.—The pedunculated tumor from the stomach prolapsing into the duodenum.

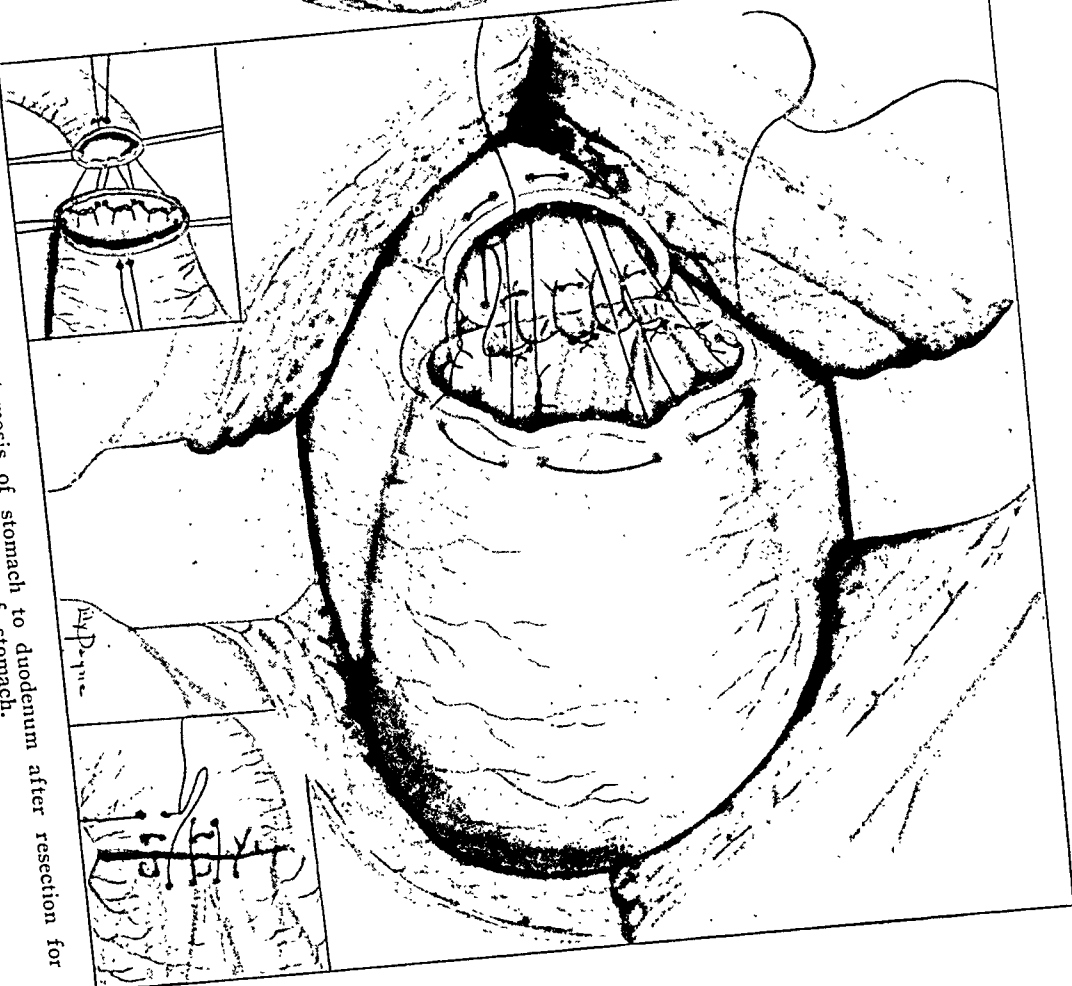


FIG. 3.—End-to-end anastomosis of stomach to duodenum after resection for pedunculated tumor of stomach.

mucosa 5 centimetres long and $2\frac{1}{2}$ centimetres high, wedge-shaped, continuous as a polypoid mass $2\frac{1}{2}$ centimetres in diameter, mucosal covered, occupying the orifice of the distal extremity. Attached lymph glands are moderately enlarged.

Microscopic description.—Pronounced mononuclear cell infiltration, among which plasma cells are numerous, diffuse and intense about bases of ulcers, focal and bulky—chiefly perivascular—throughout other strata. An occasional gummatoid focus occurs, chiefly submucous in position. Endothelial hyperplasia and endarteritic intimal thicken-

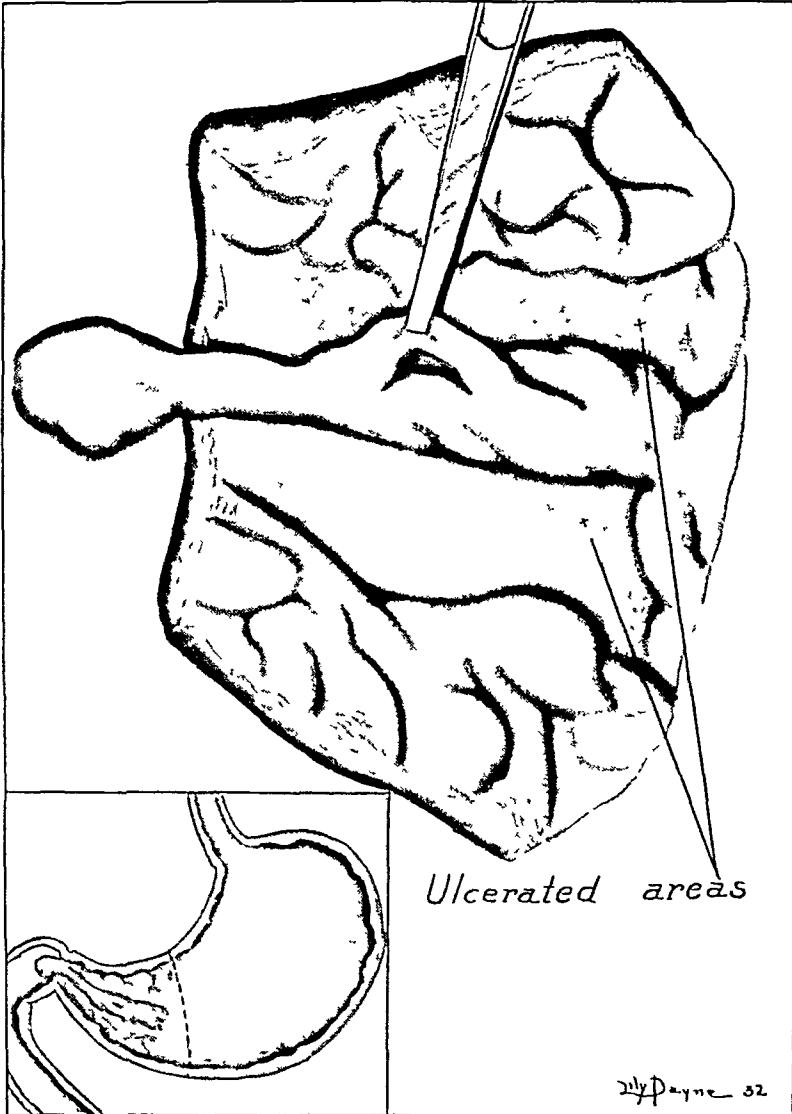


FIG 4—Pedunculated hypertrophied mucous membrane of the stomach prolapsing into the duodenum

ing are seen in blood vessels. It is improbable that the reaction is non-specific. Polypoid masses have an organized hypertrophied mucosal structure, not neoplastic.

Pathological diagnosis.—Syphilis of the stomach with ulceration and polypoid hypertrophy of mucosa.

His convalescence was normal. He was out of bed on the eighth day. Röntgenological examination made three weeks following operation showed his stomach functioning well. He has remained well up to the present time, with the exception of one

BENIGN TUMORS OF STOMACH

night about six weeks after operation; after overeating he had an attack of vomiting for which he was kept in the hospital three days for observation.

March 17, 1932, four months after operation, the röntgenological report is as follows: There has been a resection of the pylorus and the first portion of the duodenum with an end-to-end anastomosis. The stomach and the site of the anastomosis are entirely free of defects and pathology. There is free and rapid emptying, and the stomach is entirely empty at six hours. There is a slight hypermotility of the barium meal, but the gastric function is entirely satisfactory.

The subject of benign tumors of the stomach has been extensively studied for less than ten years. Eliason, Pendergrass, Miller and Wright, working as a group in Philadelphia, have personally encountered more than eleven cases; Balfour and his co-workers have reported fifty-eight cases from Rochester up to 1927; Lockwood reports twelve cases seen during the past seven years; Meyer and Singer, from Chicago, and Matas, from New Orleans, have given beautiful descriptions of prolapsing tumors and mucous membrane of the stomach into the duodenum. A great many scattered and isolated cases and small groups of cases are reported in literature. The disease, like many other so-called rare affections, will be found to be not so rare when carefully and specifically looked for.

The outstanding facts may be summarized for consideration.

The lesions will be found to include practically all types of benign tumors, varying greatly in size, occurring in any part of the stomach, with great frequency found on the mucous and submucous coats and may be pedunculated. They are most frequently found in the pyloric portion of the stomach, least frequently in the cardiac area, and are often multiple. They may occasionally undergo sarcomatous or cystic changes, or may be associated with cancer, which at times appears to be an effect of transformation of benign into malignant disease.

Frequently the tumor will consist of a large area of hypertrophied membranous mucous membrane. Although this type of pathology cannot be classed histologically as a true neoplasm it is productive of the same symptoms, and commands the same treatment.

Ulcer is a frequent associated condition. Usually the ulcer is at the base of the tumor, occasionally at some distance away. Cancer was found to be a secondary development in 35 per cent. of 23 cases subjected to thorough examination according to the reports of Miller, Eliason and Wright. Other observers have noted much lower incidence of malignancy.

In cases of clinically recognized cancer of the stomach, approximately 4 per cent. are believed to have been originally benign tumors; and Ewing suggests that all bulky polypoid carcinomata may have been in the early stages benign polyps.

As to the etiology of benign tumors of the stomach, little is actually known, and much explanation offered. In the case of localized hypertrophied mucous membranes, certain factors such as low-grade inflammatory reaction, and especially syphilis, are offered as explanation. Syphilis has been mentioned probably more frequently as a cause than any other single factor.

So far in all the cases reported, the Wassermann reaction was negative or not stated. In our case the Wassermann was strongly positive and the pathological studies would indicate that the underlying etiology was syphilis. This is the only case in which this seems to be the undoubted etiology.

The effects of peristalsis may be a factor in producing prolapse either of the pedunculated tumor or mucous membrane hypertrophy through the pyloric canal into the duodenum. When peristaltic contraction occurs, the pedicle of the tumor may become stretched toward the pylorus and finally may be elongated sufficiently to permit prolapse into the duodenum.

The clinical symptoms are those of abdominal indigestion, recurrent pain, nausea and vomiting, often of blood, and anæmia; in a word, the symptomatology of dyspepsia, ulcer disease or cancer. Pyloric obstruction of an intermittent character, by a ball-valve type of tumor with pedicle, will produce a characteristic syndrome of gastric crisis or ileus as was observed especially by Matas and by Meyers and Singer.

Diagnosis must be made by röntgenologic studies. A carefully conducted fluoroscopic and röntgenographic examination must be combined. The patient should be examined in the vertical and the horizontal positions, and especially in the right oblique prone position. The latter is especially important for the detection of prolapsing tumors, hypertrophied gastric mucous membrane and true duodenal tumors. Moore advocates the following procedure: The stomach should be observed carefully as it fills, and should be scrutinized from every direction, as a tumor in the cardiac portion may cause a splitting of the barium column. Forceful palpation with the abdominal musculature relaxed enables the walls of the stomach to be approximated and a filling defect is more easily detected. If too much barium is present small growths and small lesions may be overlooked. Although there is no "type characteristic" by which tumors of the stomach can be differentiated, benign tumors give röntgen appearances which, though not always conclusive, form a reasonable basis for diagnosis. The filling defect is that of a circumscribed or punched-out defect in the barium shadow, usually on the gastric wall, leaving the curvatures regular and pliant. Peristalsis is not interfered with and the rugæ are obliterated at the point of origin of the tumor. There may be an associate niche of an accompanying ulcer. A non-complicated growth will not show a niche and there will be no incisura.

Benign tumors near the pylorus possessing sufficiently long pedicles may prolapse into the duodenum. The duodenal defect may be a central circular, oval or multilocular radiolucency completely surrounded by a thin shell of the opaque mixture. Usually there is no disturbance of the contour of the bulb. There is no prepyloric deformity or filling defect and there is a six-hour residue, slight or considerable, depending on the amount of obstruction produced. This type of tumor must be differentiated from true duodenal tumors which cause similar filling defects in the duodenal bulb. Golden attaches considerable importance to the presence or absence of a six-hour residue in differentiating these two conditions. A filling defect suggesting

a new growth in the duodenal bulb, accompanied by a six-hour residue, is indicative of a prolapsing tumor, while the absence of the six-hour residue is indicative of the tumor arising in the duodenum itself. The value of this sign is not absolute, but has been of tremendous diagnostic importance in practically all cases reported to date. Rigler observed under the fluoroscopic screen the actual prolapse of a benign growth of the stomach. He demonstrated the defect in the erect position, and there was no six-hour residue. The case of metastatic sarcoma, previously reported by us, caused a filling defect in the duodenal bulb which was demonstrated in the erect position and produced a considerable six-hour residue in the presence of a markedly dilated and atonic stomach. The finding has proven too valuable to be disregarded because of several exceptions. A larger series of case reports will determine its real value as a differential diagnostic finding.

The röntgen findings in cases of prolapsing mucous membrane have been adequately described by Eliason, Pendergrass and Wright and are strikingly different from those of pedunculated prolapsing neoplasms. Our case had all the characteristics described by these authors. (Fig. 1.) There is a prepyloric deformity determined by the amount of the hypertrophy of the pyloric structures. If a large amount of membrane is hypertrophied, the immediate one or two inches of the pyloric area will show a large filling defect, with or without the presence of barium. The defect may be very irregular, presenting a serrated appearance that may be misinterpreted as carcinoma. If the amount of hypertrophy is small, we may see enlarged rugal markings, the appearance being similar to that produced by pressure of the spine on the barium-filled stomach. A smaller amount of hypertrophy causes a thinning of the barium at this point, as compared with the remainder of the barium-filled lumen of the stomach.

If the attached area of hypertrophy has been lengthened out and formed a polypoid mass projecting through the pylorus into the duodenum, two filling defects will be observed; one in the bulb being due to the prolapsed polypoid growth; the one in the pylorus being due to the large redundant collar of mucous membrane. There is always a gastric residue, the amount depending upon the amount of pyloric obstruction and the secondary effects upon the function of the stomach.

The differential diagnosis of benign tumors must consider all those conditions which may involve the pylorus and the duodenum. The clinical course, dangers and treatment of the disease, are readily demonstrated in all cases which have been adequately reported. It is scarcely conceivable that it is spontaneously curable. The clinical symptoms are subject to periods of exacerbation and remission in intensity. The fact that nearly all of these tumors are located in the active pyloric portion of the stomach accounts for the active symptomatology. The patient has signs resembling those of ulcer, and ulcer actually exists in more than two-thirds of the cases, and cancer is found often enough. Hæmorrhage is practically always present, either as occult blood found in the stomach or intestinal contents, or in great fre-

quency in the form of a massive and near-fatal hæmorrhage. Secondary anæmia, resulting from slow bleeding over a long period of time, has been mistaken by competent clinicians as pernicious anæmia, until the true condition had been recognized by the röntgenologist.

The gastric crisis resulting from pyloric blocking of the prolapsing tumor, always productive of serious consequences, was nearly fatal in the case of Matas, complicated by intussusception.

The chief dangers of death in benign tumors may be summarized as: Hæmorrhage, pyloric obstruction and cancer.

Treatment.—These well-known diagnostic difficulties furnish food for thought when we see so many cases of ulcer disease fail to respond to treatment by the rigid dietetic, medicinal and other remedies employed in the exacting regimen implied by the medical treatment of ulcer. The so-called "ulcer syndrome" upon a basis of tumor, cannot be cured without operation. When the abdomen is opened and ulcer demonstrated, the stomach should be thoroughly examined, sometimes through an incision into its cavity, before the existence of tumor can be denied. The question as to whether the operation should remove only the tumor or the pyloric portion of the stomach can be answered by a brief consideration of the pathology of the disease and a reference to the results of treatment of reported cases. The fact that the lesions are multiple, associated with ulcer, and frequently lead to cancer, calls for excision of the pyloric region of the stomach. In only the exceptional case, could removal of only the tumor be expected to cure. With the modern technic employed in resection of the stomach for benign disease, the mortality is extremely low. The Haberer method of end-to-end, or the Finney method of end-to-side anastomosis of the stomach to the duodenum, should be applicable to all cases save those in which the coincident ulcer is located too far away from the pylorus. An occasional case of this sort may necessitate the Polya or Balfour method of anastomosis.

BIBLIOGRAPHY

- Balfour and Henderson: Benign Tumors of the Duodenum. *ANNALS OF SURGERY*, January, 1929.
- Balfour and Henderson: Benign Tumors of the Stomach. *ANNALS OF SURGERY*, vol. cxxxv, 1927.
- Cabot Case Records, No. 17072, *New England Medical Journal*, vol. cciv, pp. 328-331.
- Carmen: Syphilis of the Stomach in Its Roentgenological Aspects. *American Journal Syphilis*, vol. i, 1917.
- Eliason and Wright: Benign Tumors of the Stomach. *Surg. Gynec., and Obst.*, vol. xli, pp. 461-472, 1925.
- Eliason, Pendergrass and Wright: The Roentgen Diagnosis of Pedunculated Growths and Gastric Mucosa Prolapsing through the Pylorus. *Amer. J. Roent. and Radium Therapy*, vol. xv, 1926.
- Eliason and Miller: *Archives Internal Medicine*, November, 1930.
- Emmert: Myoma of the Stomach, Report of Unusual Case. *Nebraska State Medical Journal*, August, 1931.
- Enfield: Pedunculated Intra-Gastric Tumor, Case Report. *Amer. J. Roent. and Radium Therapy*, vol. xxv, 1931.

BENIGN TUMORS OF STOMACH

- Eusterman: Gastric Syphilis: Observations Based on Ninety-three Cases. J. A. M. A., vol. xcvi, pp. 174-181, 1931.
- Finney and Finney, Jr.: Papilloma of Duodenum. ANNALS OF SURGERY, January, 1931.
- Golden: Non-Malignant Tumors of the Duodenum. Amer. J. Roent. and Radium Therapy, vol. xx, 1928.
- Jones: Benign Tumors of the Stomach. Proc. Staff Meet., Mayo Clinic, August 29, 1928.
- Judd: Surgical Clinics of North America, February, 1929.
- LaRoque and Shiflett: ANNALS OF SURGERY. In Press.
- Levy: Benign Tumors of the Stomach, Case Report. Radiology, vol. xiii, pp. 454-457.
- Lockwood: J. A. M. A., March 19, 1932.
- Mason and Dwyer: Benign Tumors of the Stomach. ANNALS OF SURGERY, vol. lxxxviii, 1928.
- Matas: Pediculated Polypoid Fibro-adenoma of the Stomach of Ball-valve Type Causing an Unusual and Complex Syndrome. Surg., Gynec., and Obst., vol. xxxii, pp. 723-731, 1923.
- Meyer and Singer: Surg., Gynec., and Obst., December, 1931.
- Moore: A Roentgenologic Study of Benign Tumors of the Stomach. Amer. J. Roent. and Radium Therapy, vol. xi, pp. 61-66, 1924.
- Morgan: Hæmorrhage and Death from Gastric Myoma. Brit. Med. J., July 4, 1931.
- Mudholtz: The Roentgen Diagnosis of Hyperplasias. Radiology, vol. xvii, pp. 514-519, 1931.
- Nelson: A Partially Ossified Fibroma of the Stomach Wall. Brit. J. of Surg., vol. xviii, pp. 660-664, 1930-1931.
- Pendergrass: Prolapse of Pedunculated Tumors and Gastric Mucosa through the Pylorus into the Duodenum. J. A. M. A., vol. xciv, pp. 317-321, February 1, 1930.
- Rigler: Roentgen Observation of Benign Tumor of the Stomach Prolapsing through the Pylorus. Amer. J. Roent. and Radium Therapy, vol. xx, 1928.
- Smithes: Syphilis of the Stomach. Amer. J. of Syphilis, vol. i, pp. 100-110, 1917.
- Strauss, Meyer, and Bloom: Gastric Polyposis; a report of two cases with a review of the literature. Amer. J. Med. Society, vol. clxxvi, pp. 681-690, 1928.
- White and Judd: Lipoma of the Stomach, Report of a Case. Amer. J. Surg., vol. xxiv, November, 1930.

ADVANCED GASTROJEJUNAL ULCER *

BY WILLIAM L. ESTES, JR., M.D.

OF BETHLEHEM, PA.

GASTROJEJUNAL ulcer still remains a problem of absorbing interest to the abdominal surgeon. From the welter of work in gastric surgery comes no unanimity of opinion as to its incidence and cause or prevention. Its surgical treatment has been undertaken with increasing boldness, as seldom is much gained by medical measures; and yet satisfactory solution of the best procedure in the case in hand, not only to relieve the existing condition, but to prevent recurrence, may tax the ingenuity and judgment of the operator to the limit.

Occurrence.—Gastrojejunal ulcer occurs almost exclusively in men, as so far no case has ever been reported in a woman (Walton²²). Smead,[†] however, refers to the case of a woman in whom a gastrojejunal ulcer, proved at operation, developed two and one-half years after a gastroenterostomy. It most commonly has its origin in a previously performed gastroenterostomy, though it may follow also a partial gastrectomy. The antecedent lesion has almost invariably been a duodenal ulcer. Balfour¹ states that gastrojejunal ulcer is almost unknown following excision, and gastroenterostomy for *gastric* ulcer. Key¹⁰ has recorded a case as jejunal ulcer after gastroenterostomy for gastric carcinoma, but Wilkie²³ believes the evidence is unconvincing. It may arise within a few months, more often within two to three years of the primary operation or even later; Moynihan¹⁷ states it is usually within two years, but Luff,¹³ in his exhaustive report, finds 38 per cent. occur within two years and 62 per cent. from two to eight years.

Statistics of its incidence vary. In the early reports, notably that of Van Roojen,²¹ in 1910, marginal ulcer was found in 1.58 per cent. of gastroenterostomies, and more commonly in the anterior operation. It seems more likely to occur when artificial pyloric occlusion is done at the same time. More recent figures show a wide variation. After gastroenterostomy, Moynihan¹⁶ has found gastrojejunal ulcer in 1.84 per cent. Rowlands¹⁹ reported 2 per cent. Luff,¹³ in his report for the British Medical Association on the after-history of gastroenterostomy, based on 995 cases from numerous operators, reported gastrojejunal ulcer in 2.8 per cent. Nystrom¹⁸ quotes German statistics as showing 3 per cent. In this country Gibbon⁷ cites less than 1 per cent.; Douglas,⁵ 1.6 per cent.; Horsley,⁹ 3 per cent.; Hartwell,⁸ 3.7 per cent.; St. John,²⁰ 6.9 per cent. Lewisohn¹² claims a percentage varying from 12 per cent. to 34 per cent. Balfour,¹ in studying ten-year end-results in 491 cases, found gastrojejunal ulcer in 3.26 per cent.

* Read at the meeting of the Johns Hopkins Surgical Society, February 5, 1932.

† Personal communication.

The percentage of marginal ulcer following gastric resection is given by St. John²⁰ as 3.6 per cent. Balfour^{2, 3} quotes Bergfeld as reporting fifty-three cases from the literature and reports thirty-one cases from the Mayo Clinic. Of these latter, eighteen followed some type of gastrojejunostomy.

Etiology.—(1) Lack of proper after-treatment. Improper diet and régime. (2) Persistent hypertonic and hyperacid stomach, often from excessive smoking or use of alcohol, *etc.* (3) Remaining foci of infection which may have caused the original ulcer and similarly cause the jejunal ulcer. (4) Infection at the suture line. (5) Anatomical errors at the stoma. Badly placed stoma or badly chosen type of operation. Lack of accurate approximation of the mucosa. Submucous hæmatoma particularly at the cardiac angle of the stoma (Montgomery¹⁵). (6) Some constitutional defect that permits repeated formation of ulcers, *i.e.*, some nervous or trophic disturbance. Patients that have a peculiar liability to the formation of ulcer. (7) Use of non-absorbable sutures in the mucosa, and improper application of clamps.

These may be summarized as consisting really of three definite groups: (1) Improper after-treatment. (2) Errors in operative technic. (3) Constitutional tendency to form ulcer.

It is said that gastrojejunal ulcer is exceptionally prevalent in Spain because of the difficulty in supervising proper after-treatment. (Casanova-Seco.⁴)

Pathology.—The ulcer is usually in the line of anastomosis, but may occur in the jejunum within two to three centimetres of it, where it has a great tendency to perforate. It may involve only a small portion of the stoma or its entire lumen with very extensive inflammatory infiltration of the adjacent mesocolon, and, finally, it may partly or completely close the stoma or perforate into the colon to form a gastrocolic fistula. It has a great tendency to bleed. Fohl⁶ states that blood in the stool is never absent. Hæmorrhages are often profuse; there is usually melena and tarry stools, but never hæmetemesis. Even after extensive resection for a marginal ulcer, when a new gastrojejunostomy of some sort has been done there is a great tendency to recurrence.

Symptomatology.—The characteristic symptoms of gastrojejunal ulcer are pain one-half to one and one-half hours after eating, similar to or more severe than the original ulcer pain, the pain being located to the left of the mid-line in the epigastrium; *i.e.*, at the location of the ulcer. There will be tenderness at this point on palpation. Vomiting may occur when there is obstruction at the stoma. As in other types of ulcer there may be a great tendency to remission of symptoms and periodic recrudescence. The pain may often be relieved by food or alkalis but occasionally by neither. Clinically, there are two types: (1) Acute fulminating perforation of a jejunal ulcer close to the stoma with no premonitory symptoms. (2) Slowly infiltrating and perforating marginal ulcer with periodic exacerbation of symp-

toms, and an insidious course of remissions with finally perforation into the colon or stomach.

A gastrocolic fistula may be suspected when there are foul eructations and fecal vomiting, with diarrhoea, the stools showing undigested food. The X-ray may aid in the diagnosis by demonstrating a deformed or painful stoma or obstruction, if any is present, and a barium enema can demonstrate a gastrocolic fistula, but usually the diagnosis must rest upon the characteristic symptom complex.

Treatment.—While medical measures may give temporary relief, there are few, if any, cases cured without surgery. Surgical procedure depends upon the type of lesion found. It may be: (1) Closure of a perforated ulcer. (2) Preliminary jejunostomy. (3) Simple excision of ulcer. (4) Excision of ulcer and abolition of the stoma. (5) Excision of ulcer and abolition of stoma and gastroduodenostomy or pyloroplasty. (6) Pylorectomy. (Koch.¹¹) (7) Partial gastrectomy with abolition of stoma, followed by a Polya or a Roux type of anastomosis. (8) For gastrocolic fistula. (a) Extensive resection of stomach, colon and jejunum. (b) Resection with restoration of stomach and duodenum and colostomy or simple closure of the opening in the colon.

When the original duodenal ulcer is found to be healed and the marginal ulcer small, abolition of the stoma with excision of the ulcer is the most satisfactory operation; rarely will simple excision of the ulcer suffice. When the duodenal ulcer is still present, abolition of the stoma with resection of the marginal ulcer should be supplemented by a pyloroplasty or gastric resection.

In advanced gastrojejunal ulcer, so-called "protected perforated" cases (Balfour) with wide inflammatory reaction in the mesentery of the colon, Mayo-Robson,¹⁴ formerly, and Balfour,³ more recently, have advocated a preliminary jejunostomy for feeding, to permit by rest of the ulcer area recession of the reaction and partial healing of the ulcer, so that a later resection may be more easily and safely undertaken.

For operation on an ulcer recurrent in the stoma following gastric resection and in repeated recurrent ulcer a Roux or Y type of anastomosis may offer the best solution. Balfour³ has stated that in re-operation: (1) Trauma to the mucosa must be kept at a minimum. (2) There should be a radical change in the type of anastomosis. (3) Added jejunostomy for feeding must be considered. (4) Careful post-operative treatment should include proper diet, elimination of all foci of infection, and no alcohol or tobacco.

Case Reports.—The present report is based on two cases in neither of which did any of the above procedures seem applicable. A brief résumé follows:

CASE I.—Male—aged forty-three years, married. Admitted April 10, 1930. For six months previously he had had typical symptoms of gastrojejunal ulcer. Pain in epigastrium and to the left, fairly constant, colicky at times, worse with constipation. Vomits almost every evening one and one-half hours after evening meal food eaten dur-

ing day. Appendectomy fifteen years ago. Six years later he had a ruptured duodenal ulcer with gastroenterostomy. Also, recently he had pain in the epigastrium fifteen to twenty minutes to two hours after meals. He belches frequently and has gnawing pain at times. He has had jaundice for the last three days.

Examination.—Undernourished. Icteric tint to scleræ. Marked epigastric tenderness. No rigidity. Pyorrhœa and a few non-vital teeth. Icterus index, 13.

Clinical course.—Jaundice increased in next four days. Vomited foul material at times. Soreness on right and left upper abdomen persisted. *Wassermann.*—Negative. Gastric analysis: Slightly high acid curve. Coagulation time, five and one-half minutes. X-ray shows old stoma with extensive gastrojejunal ulcer. No gall-stones. A two-stage operation was deemed advisable: (1) To relieve jaundice. (2) To cure marginal ulcer.

Operation I.—Right rectus incision. Cholecystostomy. Marked adhesions about gall-bladder, cholecystitis grade 2. No stones. The glands at the cystic duct were enlarged. Common duct was negative. Head of pancreas was thickened. No duodenal ulcer. Large gastrojejunal ulcer.

Post-operative course.—Normal convalescence. Gall-bladder drained well and jaundice cleared up. Closure of fistula in three weeks.

Operation II.—Left rectus incision. Ulcer found involving the complete circumference of the gastroenterostomy stoma fully one centimetre of induration about it. Marked mesenteric thickening and pulling down of colon toward it. Gastroenterostomy was taken down by freeing the stomach from above through an opening in the gastrocolic omentum, and the jejunum was trimmed away from below, leaving the ulcer attached to the orifice in the mesentery, 3 inches of jejunum resected. The ulcer area was cauterized and drained. Stomach closed. Jejunum reunited. Very little, if any, bleeding at any time from the ulcer. Drainage tract healed promptly. Uneventful convalescence.

Follow-up report.—Two years later—quite normal. No further jaundice nor symptoms of recurrence.

Comment.—As there was no evidence of a persistent duodenal ulcer, merely abolition of the stoma seemed indicated, and resection of the colon and its mesentery unnecessary. The only innovation in surgical solution of this particular problem was simple cauterization of the completely isolated marginal ulcer still attached to the mesentery, instead of resection. Separation of the stoma from the mesentery of the colon promised to be exceedingly difficult and likely to produce extensive hæmorrhage, the control of which might jeopardize the circulation of the transverse colon; therefore the above expedient was resorted to.

CASE II.—Male, aged forty years, admitted August 2, 1931, suffering off and on for fourteen years with symptoms of a duodenal ulcer. In 1927, he was first operated upon and a large ulcer on the posterior wall of the duodenum was found three to four centimetres from the pylorus and adherent to the pancreas. Appendectomy and posterior gastroenterostomy. *Wassermann.*—Negative. He made a normal convalescence and went home on the twelfth day.

Five and one-half months later he had sudden acute excruciating pain, without previous symptoms. Immediate operation revealed a perforated jejunal ulcer in the distal loop of the jejunum two centimetres below the gastroenterostomy stoma. The perforation was closed and covered with omentum. Drainage. Uneventful convalescence.

Six months later he returned with symptoms of gastrojejunal ulcer. He improved rapidly under medical treatment. Refused operation. Two years later he had an operation for post-operative hernia. At this time X-ray showed gastrojejunal ulcer and beginning six-hour retention, but patient again refused further operation. One year later, or three months ago, he had acute intestinal obstruction from adhesions about the old jejunal perforation. These adhesions were released. For five weeks he had acute epigastric and left lumbar pain from which vomiting gave relief, becoming more intense and persistent. Another operation for intestinal obstruction was performed and only a

few adhesions of the transverse colon were found. These were released. Ten days later he came into my hands. He had suddenly begun to vomit huge amounts of brown fluid, 500 to 750 cubic centimetres, with extreme epigastric pain and hard tarry stools. His hæmoglobin was 37 per cent., 6.5 grams per 100 cubic centimetres and his red blood cells were 2,620,000. The X-ray showed large six-hour gastric retention with irregular gastroenterostomy stoma. Occult blood in stools. On a milk diet, with daily lavage and two blood transfusions he improved markedly.

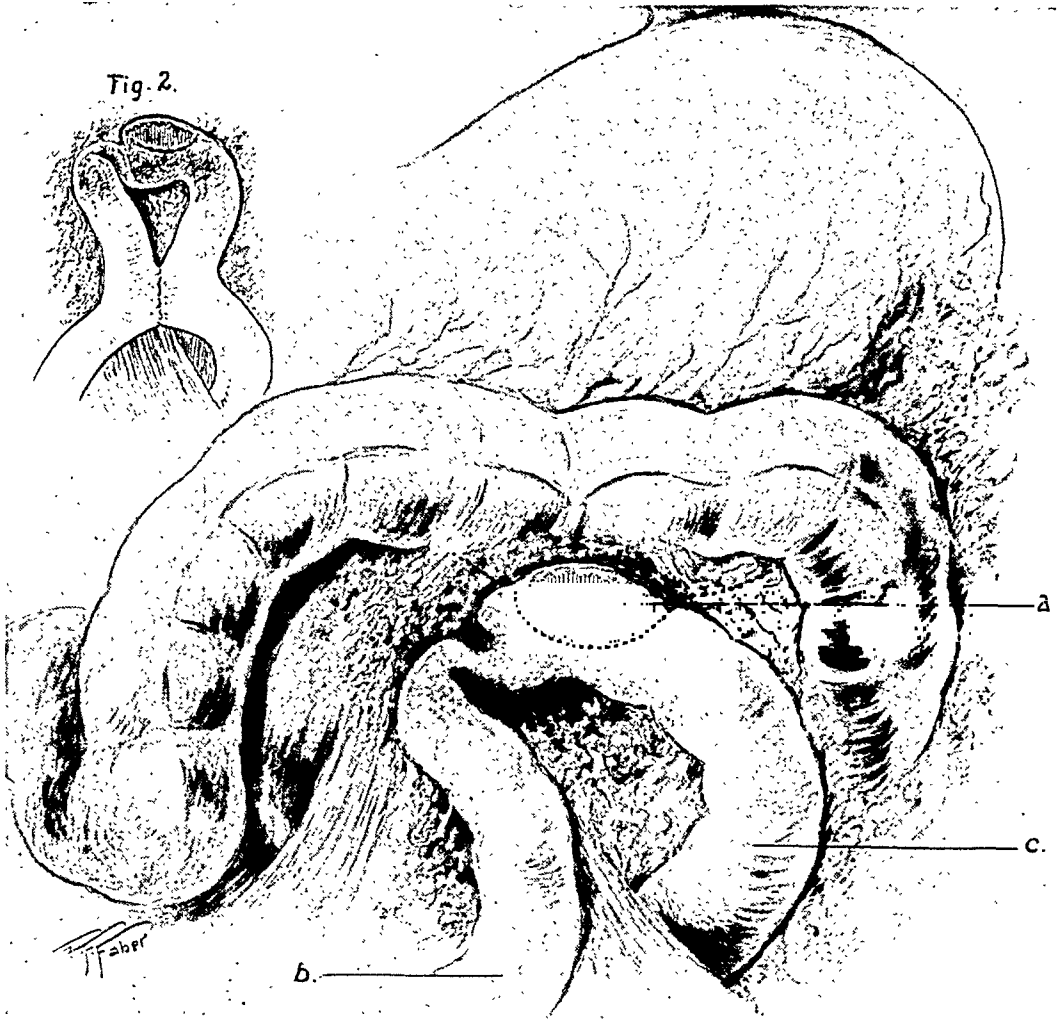


FIG. 1.—(a)—The stoma and gastrojejunal ulcer in Case II, with wide induration about it and showing its proximity to the colon. (b)—The distal loop of jejunum with obstruction and kinking just beyond the stoma. (c)—The dilated proximal jejunum.

FIG. 2.—(Small insert.) The anastomosis of the jejunum around the ulcer.

Operation.—August 24, 1931. A huge thickened ulcer around the entire old gastroenterostomy stoma with extreme induration and thickening for fully four centimetres in the mesocolon around it, extending to the base of the mesocolon and pulling the transverse colon down against the ulcer. At the distal margin of the stoma the loop of jejunum just below the enterostomy was firmly adherent to the ulcer, causing a partial obstruction of the jejunum. The proximal jejunal loop was quite dilated. (Fig. 1.) The stomach was greatly distended. Pylorus widely dilated. There was no evidence of duodenal ulcer. There were numerous enlarged glands in the jejunal mesentery. One

of the jejunal glands was removed for diagnosis and no microscopical evidence of malignancy found. The upper margin of the stoma was first exposed through an opening in the gastrocolic omentum and freed from the stomach with considerable difficulty because of the fixity of the tissues. The opening in the stomach was closed with a double layer of catgut and the stomach side of the stoma was similarly closed, but with considerable tension. The transverse colon was then lifted up and an anastomosis was made between the proximal and distal loops of jejunum six to eight centimetres from the stoma, thus restoring the continuity of the intestine around the obstruction in the jejunum and the ulcer area. (See Fig. 1 insert.) He made an uneventful recovery and went home eighteen days after the operation completely relieved.

Comment.—As the patient was still far from a good operative risk when the operation was undertaken, radical resection of the entire ulcerated area seemed out of the question, and the simplest procedure that would relieve the condition found seemed the best surgical procedure to pursue. The jejunum and stomach could not possibly be freed from the mesocolon, therefore the detachment of the stomach from the stoma and an anastomosis of the jejunum around the obstruction was decided upon, leaving the gastrojejunal ulcer really intact, but on a side track of the jejunum only; trusting that when acid gastric juice no longer came in contact with the ulcer it might heal spontaneously.

Subsequent history.—He had a normal convalescence for five weeks, when, without any premonitory symptoms, he passed bright clotted blood in stools. He began to have intermittent unlocalized low abdominal pain and severe upper abdominal pain radiating to his back, with marked belching of gas, but no vomiting.

He was re-admitted with marked tenderness in the epigastrium just below the ensiform cartilage. There was no rigidity. His hæmoglobin was 40 per cent., 6.7 grams per 100 cubic centimetres, and his red blood-corpuscles, 3,670,000. The following day he began to vomit bile-tinged fluid at night with severe cramp-like pain in the upper right abdomen, extending to his back, relieved by enema and atropine. There was no further hæmorrhage. X-ray showed a normal emptying stomach with slight irregularity in its middle third and deformity of the duodenum, probably from an old adhesion. The transverse colon was normal. A transfusion was given. It was felt that the gastrojejunal ulcer was still active and an operation for resection was advised.

At operation, October 28, 1931, nine weeks after the first operation, it was found that the stomach was slightly distended and lightly adherent to the former operative scars, but otherwise quite normal. The site of the recent jejunal anastomosis was quite free of adhesions and the gut was collapsed. The area of the old gastrojejunal ulcer was difficult to recognize; it was completely healed without a vestige of induration or ulcer (Fig. 3) and fully three to four centimetres of normal mesentery separated it from the transverse colon, which seemed normal throughout. There was, however, a large callous ulcer on the posterior wall of the duodenum, six to seven centimetres in diameter adherent to the pancreas, its proximal margin two centimetres from the pylorus. There were dense adhesions of the gastrohepatic and gastrocolic omenta over the duodenum.

Resection of the ulcer and duodenum and also pylorotomy with closure of the duodenum proximal to the ulcer were considered, but in view of the adhesions and bleeding, character, and size of the ulcer, a two-stage operation was decided upon to give the ulcer an opportunity to heal and make a subsequent resection less formidable. An anterior gastroenterostomy just proximal to the angle of the lesser curvature was then undertaken with entero-anastomosis between the loops. His convalescence was uneventful but he refused further operation.

Subsequent history.—He gained thirty-four pounds in two months and felt better than he had for five or six years. He was symptom-free until two weeks ago when he acquired an upper respiratory-tract infection. Since then he has had a little belching of gas, relieved by "baking soda." He has had no melena and no pain.

Comment.—This man evidently belongs to that group in which it has been suspected a constitutional defect or tendency gives a particular liability to the formation of ulcer. He also demonstrates that gastrojejunal ulcer, just as any peptic ulcer under favorable conditions, will readily heal.

SUMMARY.—Two cases are reported in which conservative operations

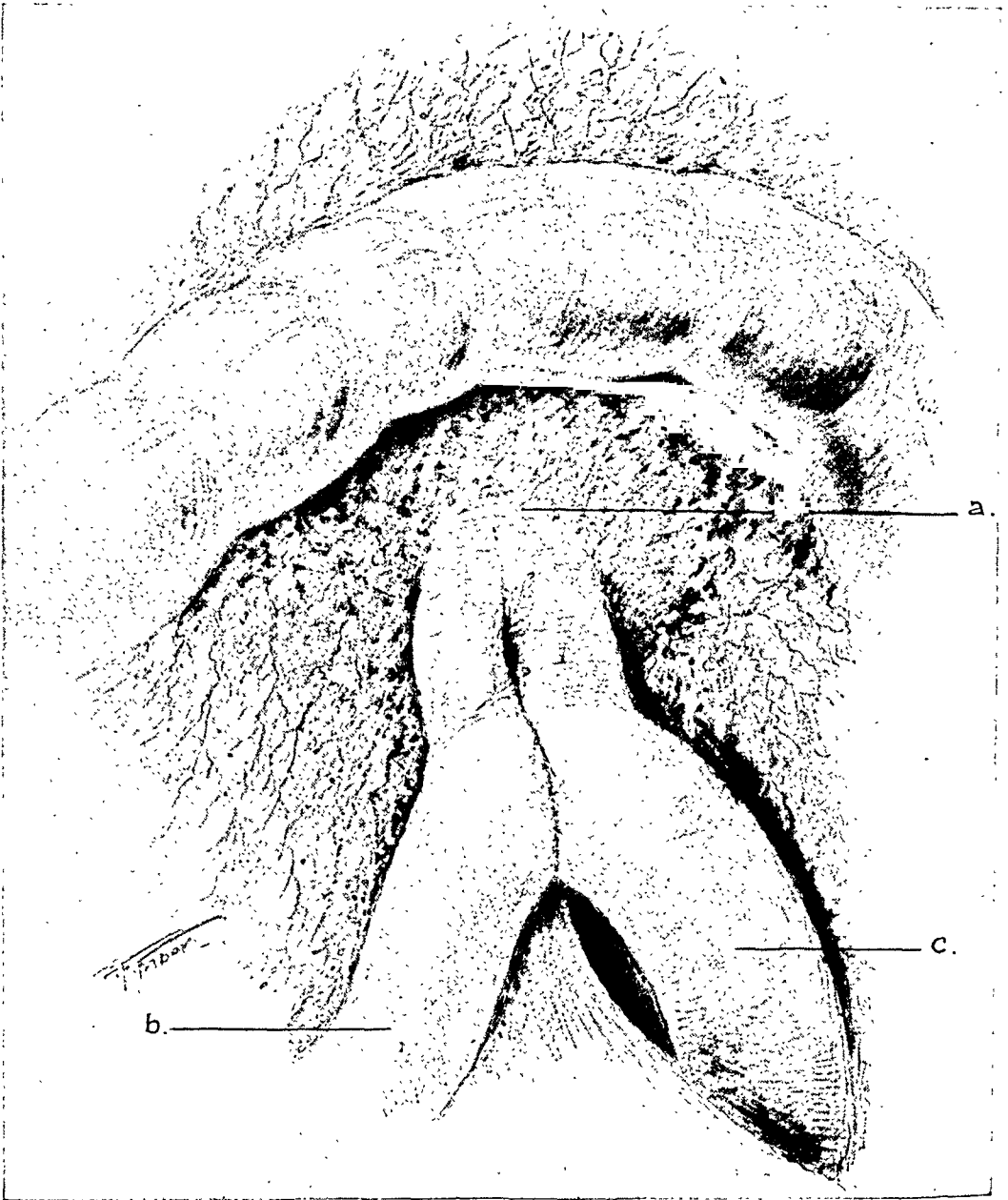


FIG. 3.—(Case II.) The findings at second operation nine weeks after the first. Collapsed "side track" of jejunum with complete healing of gastrojejunal ulcer, no vestige of which remains (a). Note normal mesocolon between colon and former ulcer area. (b) and (c)—Distal and proximal limbs of jejunum.

were used in advanced gastrojejunal ulcer of the slow infiltrating and perforative type. In one case, after detaching and closing the stomach and jejunum, the ulcer still attached to its mesenteric stoma was cauterized. This patient has remained well. In the other, after detaching the stomach from

the upper border of the stoma and closing it, a jejunojejunostomy around the ulcer area was performed with complete healing of the ulcer within nine weeks as confirmed by a subsequent operation for a recurrent duodenal ulcer. The alternative would have been a preliminary jejunostomy with a later direct attack on the ulcer or an extensive resection, including a portion of the transverse colon. Is it possible that detachment of the stomach from a gastrojejunal stoma yields the opportunity for spontaneous healing of the ulcer?

As Moynihan¹⁶ has said: "The treatment of a peptic jejunal ulcer may be beset with almost insuperable difficulties. Much will depend upon the conditions found at the time of operation." Post-operative mortality for marginal ulcer in the British series as reported by Luff¹³ was 33 1/3 per cent. It has likewise repeatedly been reiterated that especially in gastric surgery no one operation or a few favorite operations should be applied universally but that operation should be used which is particularly suitable for the individual case. The above conservative procedures have been recorded as having safely met the special problem encountered in certain particular instances of advanced gastrojejunal ulcer.

BIBLIOGRAPHY

- ¹ Balfour: Trans. Am. Surg. Assn., vol. xlviii, p. 146, 1930.
- ² Balfour: ANNALS OF SURGERY, vol. lxxxviii, p. 548, 1928.
- ³ Balfour: ANNALS OF SURGERY, vol. xc, p. 535, 1929.
- ⁴ Casanova-Seco: Progresos de la Clin., vol. xxxvii, pp. 363-385, 410-427, 1927.
- ⁵ Douglas: Trans. Am. Surg. Assn., vol. xlviii, p. 196, 1920.
- ⁶ Fohl: München. med. Wchnschr., vol. vi, p. 136, 1930.
- ⁷ Gibbon: Trans. Am. Surg. Assn., vol. xlviii, p. 181, 1930.
- ⁸ Hartwell: Trans. Am. Surg. Assn., vol. xlviii, p. 167, 1930.
- ⁹ Horsley: Trans. Am. Surg. Assn., vol. xlviii, p. 132, 1930.
- ¹⁰ Key: Nord. med. Ark., vol. xl, p. 97, 1907.
- ¹¹ Koch: Zentralbl. f. Chir., vol. liv, p. 711, 1927.
- ¹² Lewisohn: Jour. Am. Med. Assn., vol. lxxxix, p. 1649, 1927.
- ¹³ Luff: Brit. Med. Jour., vol. ii, p. 1074, 1929.
- ¹⁴ Mayo-Robson: Brit. Med. Jour., vol. i, p. 1, 1912.
- ¹⁵ Montgomery: Arch. Surg., vol. vi, p. 136, 1923.
- ¹⁶ Moynihan: Abdominal Operations, vol. i, p. 305, Saunders, 1926.
- ¹⁷ Moynihan: Quoted by Luff.
- ¹⁸ Nystrom: Trans. Am. Surg. Assn., vol. xlviii, p. 200, 1930.
- ¹⁹ Rowlands: Brit. Med. Jour., vol. i, p. 433, 1928.
- ²⁰ St. John: Trans. Am. Surg. Assn., vol. xlviii, p. 162, 1930.
- ²¹ Van Roojen: Arch. f. klin. Chir., vol. xci, p. 380, 1910.
- ²² Walton: Quoted by Luff.
- ²³ Wilkie: Edinburgh Med. Jour., vol. v, p. 316, 1910.

THE CHOICE OF SURGICAL PROCEDURES FOR DUODENAL ULCER*

BY WALTMAN WALTERS, M.D.

OF ROCHESTER, MINN.

FROM THE DIVISION OF SURGERY OF THE MAYO CLINIC

MY PURPOSE in presenting this material at this time is to direct attention to the fact that duodenal ulcer and its associated pathological lesions differ in proportion among different peoples and in different countries. I refer particularly to specimens of the stomach and duodenum removed primarily for duodenal ulceration in various German surgical clinics, in comparison with those removed at The Mayo Clinic. In April and May of 1931, while on a clinical trip abroad, I had the opportunity to study these fresh specimens and also specimens that had been removed previously.

Konjetzny¹¹ has published colored photographs and photomicrographs of specimens removed from German patients which show clearly the association of various types of gastritis with duodenal ulcer. These gastric lesions are, for the most part, of the ulcerative type (Fig. 1) and may or may not be associated with additional hæmorrhagic areas of subacute and chronic inflammation. The ulcers are more marked in the region of the lesser curvature, varying in number from a few to as many as twenty or thirty and penetrating to the muscularis mucosæ. Besides the ulcerating type, there is the hæmorrhagic type, in the early stages accompanied by hypertrophy of the mucous membrane. (Fig. 2.) Later this type appears to pass into the atrophic stage of gastritis. (Fig. 3.)

In both groups of cases, it is not uncommon to find fibrinous exudate forming a white membrane spread diffusely over the area of ulceration. In practically all instances, the areas of ulcerative gastritis are confined to the antrum or the lower third of the stomach, whereas the area of hæmorrhagic gastritis, although confined to the antrum in most cases, may occasionally extend to the middle and upper thirds of the stomach. Microscopically, the lesions are characterized by typical areas of ulceration of the mucous membrane, covered in some cases with an exudate composed of fibrin and leucocytes. Marked leucocytic infiltration of all layers of the resected antrum of the stomach is noted. The duodenal ulcers themselves, for the most part, tended to be multiple and seemed larger and more of the penetrating type than those which I have been accustomed to seeing in this country. Konjetzny and his collaborators have pointed out the constant occurrence (up to 100 per cent.) of these gastric changes associated with duodenal ulceration. Lindau and Wulff¹² recently quoted from Konjetzny as follows: "These changes in the mucosa are not secondary conditions of irritation surrounding

* Read before the Southeastern Surgical Congress, March 7, 1932.

SURGERY OF DUODENAL ULCER

the ulcer but are primary or parallel the initial stage of ulceration which is shown by the fact that gastritis is pronounced over the entire pyloric end, irrespective of the site of the ulcer (for example, in the duodenum) and by the fact that this type of gastritis (with clinical symptoms of ulcer) also occurs in cases without any ulcer."

In discussing with surgeons in Germany these associated infectious lesions of the antrum of the stomach, and mentioning their infrequency in association with duodenal ulcer in my experience, the question was raised as to whether at the time of operation for duodenal ulcer, in which pyloroplasty or gastroenterostomy was performed, one could inspect the antrum of the

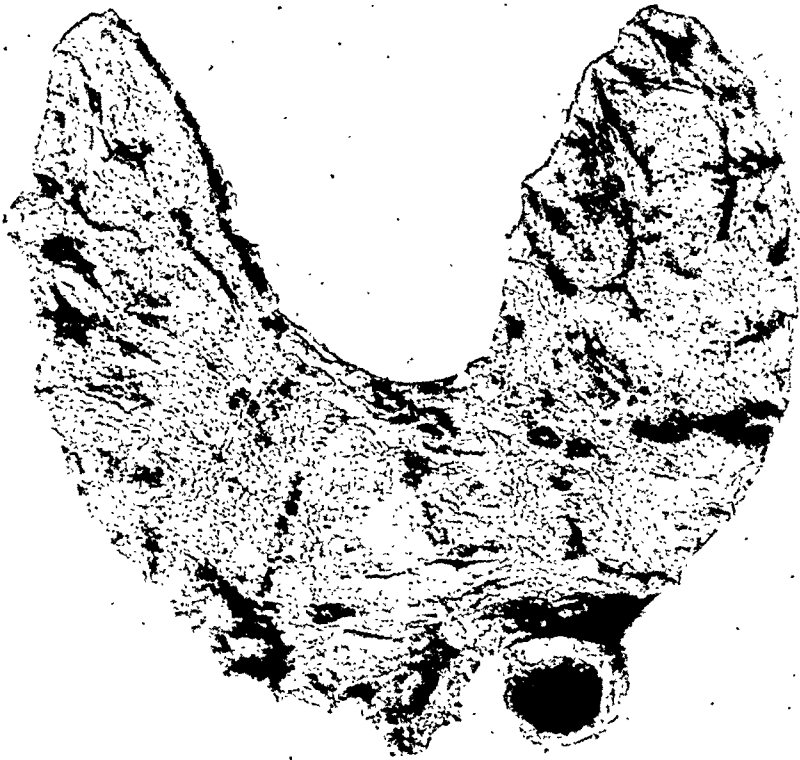


FIG. 1.—Ulcerative type of gastritis accompanying duodenal ulcer (Schmieden's clinic).

stomach sufficiently to say with any degree of certainty that such associated gastric lesions were not present. I contended that one could make such determinations. This proof I now have. Furthermore, with these gastritis lesions absent in a majority of our cases of duodenal ulcer, it would seem that not only pathologically but biologically the lesions differ in the contrasting groups. Hence surgical procedures directed toward the cure of one group of cases may not be indicated in the other.

The probabilities are that this diffuse inflammation of the stomach, for the most part ulcerative, with its higher incidence among German patients, may explain the higher incidence of recurrence of ulceration following gastroenterostomy or pyloroplasty in contrast to that found in this country. With



FIG. 2.—Hæmorrhagic, hypertrophic, ulcerative gastritis, accompanying duodenal ulcer (Schmieden's clinic).

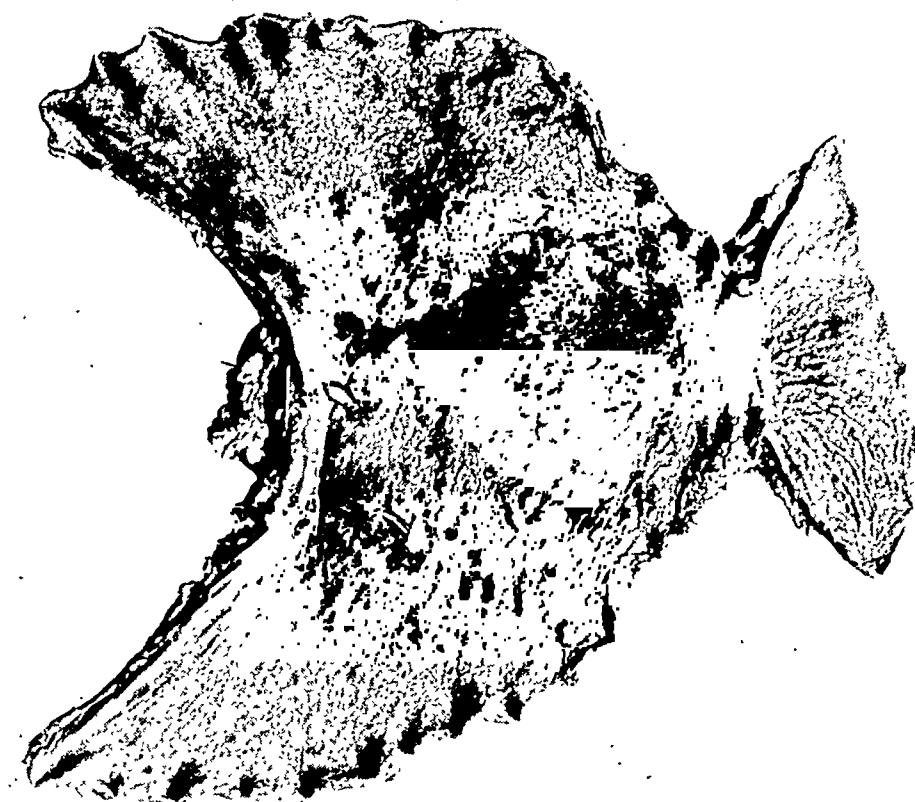


FIG. 3.—Hæmorrhagic, atrophic, ulcerative type of gastritis, accompanying duodenal ulcer (Schmieden's clinic).

a marked degree of subacute, hæmorrhagic and ulcerative gastritis present in the lower portion of the stomach, the stoma made at gastroenterostomy or pyloroplasty is placed in the area of gastritis. Hence it would seem possible that our few cases in which ulcer recurs after gastroenterostomy or pyloroplasty may be of this type, and that recurrence can be prevented if such cases are distinguished from those in which ulcerating gastritis does not coexist.

After returning home, I discussed the question with my colleagues, particularly with Balfour, MacCarty and Robertson, and it was decided that in



FIG. 4.



FIG. 5.

FIG. 4.—Hæmorrhagic, perforating (into pancreas), subacute duodenal ulcer; antrum of stomach shows no gastritis.

FIG. 5.—Resected specimen of stomach for perforated duodenal ulcers, no gastritis.

selected cases in which indications would seem to warrant resection of the stomach, such a procedure would be carried out. I have, therefore, in the last eight months, performed gastric resections of the Billroth I, and posterior Polya types for duodenal ulcer in selected cases, particularly those in which the duodenal ulceration was of the perforating, hæmorrhagic, or craterous type. (Figs. 4 and 5.) In only two of the specimens was gastritis associated; in one of them, the presence of the gastric ulcerations had been demonstrated in röntgenograms prior to operation (Figs. 6 and 7) whereas in the other, the presence of the ulceration was evidenced by the unusual thickening and congestion of the lower portion of the stomach to palpation. (Fig. 8.) This patient had had two severe hæmorrhages from the ulcer or

ulcers. In both cases necessity for gastric and duodenal resection was apparent because of the multiplicity of the lesions. With the exception of these two cases, there was no evidence of either the ulcerative or hæmorrhagic type of gastritis associated with duodenal ulcer.

In two other cases in which resections of the stomach were done for gastrojejunal ulcer, gastritis was evident, with one small superficial ulcer in one case.

That essential differences in other types of pathological lesions exist in different countries, or, indeed, in different parts of the same country, is apparent when one studies the distribution of cases of enlargement of the thyroid gland. We are all acquainted with the so-called "goitre belts" in

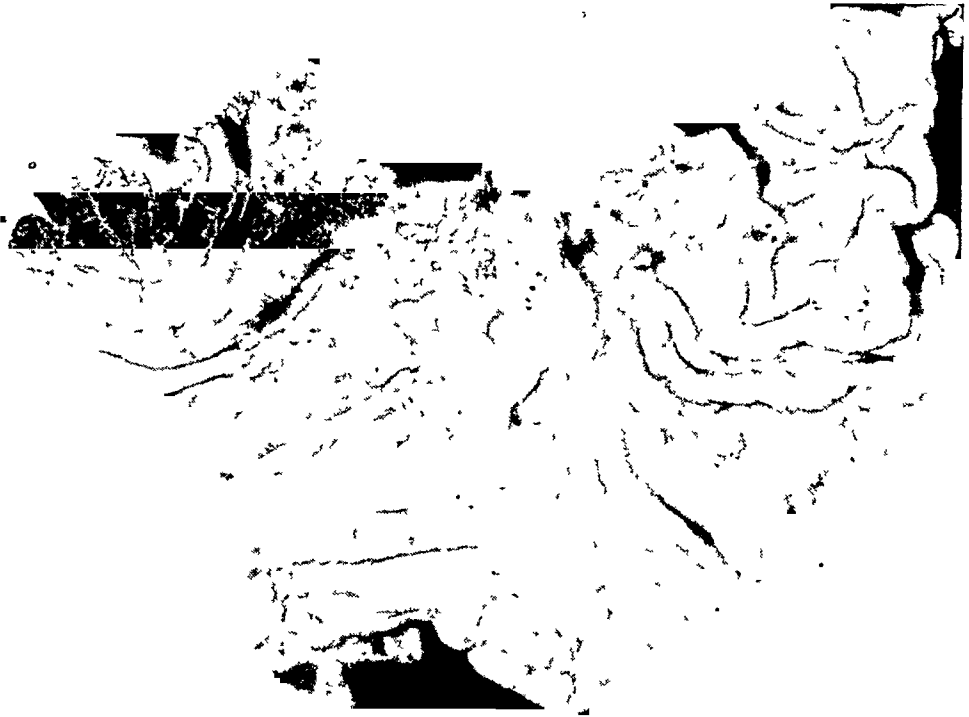


FIG 6—Duodenal ulcers with ulcerating gastritis (diagnosed pre-operatively by Röntgen ray).

this country in which the thyroid gland is excessively enlarged. Likewise, the incidence of associated hyperthyroidism is variable geographically. In Germany, in the mountainous regions near the source of the Rhine, there are said to be but few cases of exophthalmic goitre, which is in direct contrast to the proportion of goitre existing in the northern provinces of Germany along the same river. Certain surgeons⁹ have noticed that there is a marked difference in the types of duodenal ulcer and the degree of associated gastritis in two cities along the Rhine only sixty miles apart. This geographical variability is more striking when one considers that in duodenal ulcer and its associated lesions, the lesion is accompanied by an oversecretion. Further evidence of the geographical variability, possibly associated changes of metabolism, is the increasing development of calculi in the urinary tract which



62037
783284

Fig. 7.—Pre-operative roentgenogram.



Fig. 8.—Hemorrhagic duodenal ulcers with ulcerating gastritis.

has occurred in almost geometrical progression in some parts of Germany during the last ten years. For the most part, these urinary calculi exist without urinary infection, and the similarity of their percentage of development in relation to that of exophthalmic goitre in the various provinces around the Rhine, as noted by Braun, is striking in that where exophthalmic goitre has been infrequent in appearance, so has the frequency of urinary calculi been less. Further, during this same period of ten years, there has been an alarming increase in the proportion of fatal post-operative pulmonary emboli in the German-speaking countries; this increase has not occurred in some of the surgical clinics in Paris with which I am acquainted, nor has it occurred in the clinics in the United States. I have felt for a considerable period that the incidence of post-operative pulmonary embolism has a distinct relationship to metabolism, and the recent work of Bancroft and Stanley-Brown⁵ would seem to indicate that a diet high in protein tends to increase the clotting time of the blood. These facts, I believe, will add additional weight to my argument that the lesions associated with duodenal ulcer vary in different localities and among different people.

Before considering the part the presence or absence of inflammatory lesions of the antrum of the stomach associated with duodenal ulcers should play in the determination of the best surgical procedure, I should like briefly to consider the non-surgical methods of treatment of duodenal ulcer.

There seems to be little doubt that in the majority of cases, acute duodenal ulcer, with mild symptoms of short duration, can be adequately controlled by proper maintenance of the relationship between diet, habits, and neutralization of gastric acidity. The patient with chronic duodenal or gastric ulcer, however, who has failed to respond to non-surgical methods of treatment, producing symptoms interfering with the proper carrying out of the patient's work or other activities, should be treated surgically. Such being the case, the earlier a proper surgical procedure is carried out in indicated cases, the sooner the patient can return to full work.

I am rather of the opinion that during the last few years, more credit has been given to the so-called medical treatment of chronic duodenal ulcer than is justly due it. This has not been entirely the result of the enthusiasm of the internist and the gastroenterologist. I think that the tendency of German surgeons to favor partial gastrectomy, and its adoption by a few surgeons in this country as a routine procedure for cases of duodenal ulcer without recognition of variable pathological changes, have obscured the fact that excellent results are obtained in 90 per cent. of cases in this country in which conservative surgical procedures are adopted. Such conservative procedures are gastroenterostomy or pyloroplasty, with excision of the duodenal ulcer, which one should be able to carry out with an operative risk of mortality of approximately 1 per cent.

Quoting from a paper by Urban Maes¹⁷ on "The status of surgery for peptic ulcer; impressions gained from the 1930 symposium of the American Surgical Association": "Gastroenterostomy gives excellent results for duo-

denal ulcer and only slightly less good results for gastric ulcer. It is abused and it has its percentage of failures, but these facts are no warrant for the routine performance of the difficult and dangerous operation of gastrectomy for all peptic ulcers. Partial or subtotal gastrectomy, even in the most skillful hands, has a higher mortality than gastroenterostomy in an equal percentage of subsequent marginal ulcers."

In considering the place of gastroenterostomy in the treatment of duodenal ulcer, I should like to call attention to a series of three articles which appeared in the *British Medical Journal* in the latter part of 1929 and the first part of 1930, written by Dr. Arthur P. Luff,^{14, 15, 16} Consulting Physician and Director of Research, St. Mary's Hospital, London. These papers were based on a collective investigation carried out by the British Medical Association, consisting of inquiry into the after-history of patients who had been submitted to gastroenterostomy in 1920 to 1924, inclusive. Reports of 2,609 cases were received in response to the inquiry; 995 of the cases were of duodenal ulcer. The results of gastroenterostomy were reported as being very satisfactory in 89.5 per cent. of the cases. General improvement in health and well-being occurred in all but a few; secondary gastrojejunal ulcer occurred in 2.8 per cent. of the cases, and secondary hæmorrhage in 2.4 per cent., but with no fatal results. These results are practically identical with those of Balfour,^{1, 2, 3, 4} Moynihan,¹⁸ Walton²¹ and Gosset.⁸

In a symposium of the American Surgical Association, 464 cases were reported, in which pyloroplasty, with excision of the duodenal ulcer, was performed at The Mayo Clinic. Judd¹⁰ reported satisfactory results in 90 per cent. of these cases. The risk of the operative procedure was less than 1 per cent., and the operation was applicable in 50 per cent. of the cases of duodenal ulcer. A similar good record was that of Finney and Hanrahan,⁷ who reported 251 cases, in which pyloroplasty, with excision of the ulcer, was carried out with satisfactory results in 86 per cent. of the cases.

Should subacute or ulcerative gastritis involve the lower third of the stomach in association with duodenal ulcer, it would seem that the type of lesion must be entirely different, not only pathologically, but also biologically, and resection of the ulcerated portion of the stomach and duodenum must be considered. It should be remembered, however, that the average risk of partial gastrectomy, including partial duodenectomy, with removal of the duodenal ulcer varies from 5 to 10 per cent. in the hands of the most skillful and experienced surgeons, and that this risk increases proportionately to from 13 to 15 per cent., as reported from a European clinic,⁶ depending on the size, fixation, and degree of penetration and the extent of the resection of the duodenum necessary to remove it.

There is not a great deal of difficulty in performing gastric or duodenal resection when the duodenum can be mobilized easily and the duodenal ulcer has not perforated into the surrounding structures. On the other hand, if the duodenum cannot be readily mobilized, and if the lesion has penetrated into the surrounding structures, its removal would seem to carry an unwar-

rantable risk, particularly in view of the fact that a properly placed normally functioning gastroenteric stoma with an average risk of probably not more than 1 per cent., would give as great an incidence of relief of the symptoms and cure of the ulcer.

I was convinced that for surgeons operating in Germany, gastric resection was the most rational surgical procedure, especially the Billroth I type, in which the areas of ulceration of the duodenum and stomach are removed and the stomach and duodenum approximated by an end-to-end anastomosis. On the other hand, the infrequency with which such accompanying inflammations in the stomach have been present in patients operated on by me at The Mayo Clinic in the last eight years has led me to believe that in far the majority of the cases, excellent results can be expected by the conservative operation of gastroenterostomy or pyloroplasty with excision of the ulcer. These procedures can be carried out with minimal risk. Should associated inflammatory changes, especially those accompanied by ulcerations of the stomach, exist in connection with duodenal ulcer, I believe there is a place for removal of the ulcerating portion of the duodenum and stomach. This particularly applies to the bleeding type of ulcer.

I would fail in my duty after advocating such an operative procedure, if I did not direct attention to the fact that in the German surgical clinics, where subtotal gastrectomy for duodenal ulcer and its associated gastric lesions is for the most part routine, excellent results are obtained in from 80 to 85 per cent. of their cases. The 15 to 20 per cent. of cases in which there has been failure to secure excellent results were attributed by Henning to the fact that gastritis also existed in the portion of the stomach remaining after gastric resection. This was proved by gastroscopical examination. Starlinger,²⁰ following a statistical study of the post-operative results of gastric resection for duodenal ulcer and its associated gastritis, in 26,000 cases in which operation was performed at the various German surgical clinics, reported an incidence of recurring ulceration developing in from 0.6 to 1 per cent. of the cases.

The indications for various operative procedures in the treatment of duodenal ulcer, therefore, might be said to be as follows: When the duodenal ulcer is of large size and of the penetrating type, with fixation to the surrounding structures and with lack of mobility of the duodenum, and when its complete removal, with adequate closure and anastomosis of the duodenum, is difficult, gastroenterostomy is the indicated procedure. When the duodenal lesion or lesions are accessible, when the duodenum is easily mobilizable, and when gastritis is absent, excision of the duodenal ulcer or ulcers and of a portion of the pyloric sphincter gives excellent results in 90 per cent. of the cases. Resection of the stomach, or subtotal gastrectomy, has a place in removal of ulcerating lesions of the duodenum, if these are accompanied by ulcerating or hæmorrhagic gastritis, which is confined to the antral portion of the stomach.

SURGERY OF DUODENAL ULCER

SUMMARY

Portions of the stomach and duodenum, resected for duodenal ulceration, in some of the German surgical clinics, are contrasted with portions removed at The Mayo Clinic. In the lesions removed at the German surgical clinics, there was found marked associated gastritis. These gastric lesions are for the most part ulcerative in type, are confined to the antrum of the stomach, and are either associated, or not, with hæmorrhagic gastritis and hypertrophy or atrophy of the mucous membrane. Konjetzny has found gastritis to be an accompaniment of duodenal ulcer in practically all such resected specimens. In a study of the antrum of the stomach in cases of duodenal ulcer in which operation was performed at The Mayo Clinic the very infrequent association of gastritis is noted, evidence being presented by specimens removed at the time of operation.

It will stand to reason, therefore, that not only pathologically but biologically, the lesions in the two countries differ, hence the surgical procedures directed toward the treatment of one group of cases may not be indicated in the other. The probabilities are that the gastritis associated with duodenal ulcer in Germany accounts for the higher incidence of recurrence of ulceration following the conservative operations of gastroenterostomy and pyloroplasty in contrast to the low incidence of recurrence in this country. It would seem possible that the explanation for the development of recurring ulcer in the few cases (approximately 2.5 per cent.) in which it is seen, after gastroenterostomy and pyloroplasty, might be that in such cases there were associated inflammatory changes in the stomach. This small incidence of recurrence might be prevented if such cases were distinguished from those in which no ulcerative gastritis coexists. In two of our cases, associated ulcerating lesions of the stomach were known to exist. In one case they were demonstrated röntgenologically, and in the other there was palpable evidence of thickening and congestion in the lower end of the stomach. In substantiating the idea that variability in pathological lesions exists in different geographical regions, attention is directed to the variability in the incidence of toxic goitre, urinary calculi and post-operative pulmonary emboli in different parts of the world.

BIBLIOGRAPHY

- ¹ Balfour, D. C.: *Fundamental Principles in Surgery of the Stomach and Duodenum; Report of Four Hundred Cases.* Surg., Gynec., and Obst., vol. lli, pp. 167-171, February, 1926.
- ² Balfour, D. C.: *The Results of Operation for Duodenal Ulcer in Physicians.* ANNALS OF SURGERY, vol. lxxxvi, pp. 691-694, November, 1927.
- ³ Balfour, D. C.: *Results of Gastroenterostomy for Ulcer of the Duodenum and Stomach.* ANNALS OF SURGERY, vol. xcii, pp. 558-562, October, 1930.
- ⁴ Balfour, D. C.: *Annual Report of Operations on the Stomach and Duodenum for 1931.* Proc. Staff Meetings of The Mayo Clinic, vol. vii, pp. 99-102, February 17, 1932.
- ⁵ Bancroft, F. W., and Stanley-Brown, Margaret: *Post-operative Thrombosis, Thrombophlebitis and Embolism.* (In press.)

- ⁶ Burke, John: The Operative Mortality and Morbidity of Partial Gastrectomy for Peptic Ulcer. Surg., Gynec., and Obst., vol. liii, pp. 704-706, November, 1931.
- ⁷ Finney, J. M. T., and Hanrahan, Jr., E. M.: Results of Operations for Chronic Gastric and Duodenal Ulceration. ANNALS OF SURGERY, vol. xcii, pp. 620-631, October, 1930.
- ⁸ Gosset: Personal communication.
- ⁹ von Haberer: Quoted by Louria, H. W.,¹³ and Orator, Victor.¹⁰
- ¹⁰ Judd, E. S., and Hazeltine, M. E.: The Results of Operations for Excision of Ulcer of the Duodenum. ANNALS OF SURGERY, vol. xcii, pp. 563-573, October, 1930.
- ¹¹ Konjetzny, G. E.: Die Entzündliche Grundlage der typischen Geschwürsbildung im Magen und Duodenum. 155 pp., Julius Springer, Berlin, 1930.
- ¹² Lindau, Arvid, and Wulff, Helge: The Peptic Genesis of Gastric and Duodenal Ulcer. Surg., Gynec., and Obst., vol. liii, pp. 621-634, November, 1931.
- ¹³ Louria, H. W.: The Surgical Treatment of Gastric and Duodenal Ulcer. Surg., Gynec., and Obst., vol. xlvii, pp. 493-502, October, 1928.
- ¹⁴ Luff, A. P.: The After-history of Gastroenterostomy. Brit. Med. Jour., vol. ii, pp. 1074-1078, December 7, 1929.
- ¹⁵ Luff, A. P.: The After-history of Gastroenterostomy. Brit. Med. Jour., vol. ii, pp. 1125-1129, December 14, 1929.
- ¹⁶ Luff, A. P.: The After-history of Gastroenterostomy. Brit. Med. Jour., vol. i, pp. 348-354, February 22, 1930.
- ¹⁷ Maes, Urban: The Status of Surgery for Peptic Ulcer; Some Reflections Induced by the 1930 Symposium of the American Surgical Association. Am. Jour. Surg., vol. xii, pp. 1-5, April, 1931.
- ¹⁸ Moynihan, Berkeley: Some Problems in Gastric Surgery. Brit. Med. Jour., vol. ii, pp. 1021-1026, December 8, 1928.
- ¹⁹ Orator, Victor: The Billroth I Resection of the Stomach. Surg., Gynec., and Obst., vol. xlvii, pp. 368-374, September, 1928.
- ²⁰ Starlinger, F.: Personal communication.
- ²¹ Walton, A. J.: Treatment of Gastric and Duodenal Ulceration. Brit. Med. Jour., vol. i, pp. 688-689, April 21, 1928.

TUMORS OF THE SMALL INTESTINE *

BY HENRY W. CAVE, M.D.,

OF NEW YORK, N. Y.

FROM THE SURGICAL SERVICE OF THE ROOSEVELT HOSPITAL

TUMORS of the small intestine are unusual. Compared to the frequency with which growths are found in the large bowel they are rare. It seems remarkable that with cancer of the stomach so prevalent, the alimentary canal, from the pylorus to the ileo-cæcal valve, would not likewise be a frequent site for primary malignant growths. Yet there are surgeons of considerable experience who have never operated upon a benign or malignant tumor of the small intestine.

The records of the Johns Hopkins Hospital¹ reveal eighty-two cases of primary tumors between the pylorus and ileo-cæcal valve, fifty were malignant, thirty benign; a 6.5 per centage of all tumors in the gastro-intestinal tract. At the Boston City Hospital Mallory² reported eleven cases found in 4165 post-mortems. Kenneth Patterson,³ in 1929, by a careful search in the files of the Massachusetts General Hospital from 1894 to 1929 discovered forty-five cases of small intestinal tumors proven such by operation or autopsy. At the Roosevelt Hospital over a period of twenty-one years (1911-1932) we have had fourteen tumors of the small intestine. One other I operated upon in a private hospital. In the study of these fifteen cases, it was learned that unfortunately our immediate results were anything but satisfactory; our diagnosis inaccurate; our operative mortality high. We have made a careful analysis of these cases, to see wherein the diagnosis could be made more certain and our operative mortality lessened. Growths of the ampulla of Vater have not been included. Although about 70 per cent. of cancers of the duodenum begin in the peri-ampullary portion, we feel that at operation and even at the post-mortem table it is difficult to be certain that the tumor arises from the true ampulla, or whether it originates in the lower end of the common bile-duct or from aberrant pancreatic acini in the wall of the common duct or even from cells lining the pancreatic duct at its lower end. We have also excluded growths at the ileo-cæcal valve, for here again it is often confusing to determine the tumor's exact origin.

They occur at any age. In our series the ages ranged from four years to seventy-one.

More frequent in males than in females; the proportion is more than two to one.

Pathology.—Benign tumors.—Included in the group of benign tumors of the small intestine are: Those of the chronic inflammatory type, lipomas, myomas, adenomas, carcinoid or "argentaffin tumors so-called," hemangi-

* Read before the New York Surgical Society April 13, 1932.

omas, fibromas, pancreatic rests, hematomas and cysts. In our series there were two adenomas, one leiomyoma, one chronic infective granuloma, one fibroma and one case of pancreatic rest. They may develop as intraluminal or extraluminal growths. The internal tumors arise in the various layers of the bowel wall; usually benign; they grow into the lumen. They are either pedunculated or flat; grow slowly and cause few or no symptoms until they reach a size sufficient to produce obstruction or to evoke an incipient intussusception. Those developing externally arise from the serosal surface and protrude into the peritoneal cavity or, in some instances, directly into the mesentery, becoming fairly well fixed in this situation; some become the size of a foetal head lying free in the peritoneal cavity, others become firmly adherent to and involve adjacent viscera.

Another distinctive form which avoids development outwardly or inwardly are those encircling the lumen, infiltrating uniformly all coats of the intestine; chronic inflammatory lesions fall into this category, but are distinctive in that they spread continuously, in the longitudinal direction of the bowel wall; our case of chronic infective granuloma (Case IV) is a striking example of how much constriction can be produced.

The fibromata are rare. In size they vary from the dimensions of a large pea to a lemon. They have their origin in any layer of the intestinal wall, containing fibrous tissue. If pedunculated and large enough they may cause intussusception or obstruction due to blocking of the lumen. The extraluminal fibromata grow to considerable size. They are found with equal frequency in duodenum, jejunum and ileum. Our single case (Case III) of fibroma was in a woman, operated upon as an emergency for acute ileus. A fibroma $1\frac{1}{2}$ inches in diameter, of the ileum, had caused an intussusception.

The myomas are prone to bleed; in fact, severe hæmorrhages have been encountered, sufficient to endanger life, and even fatalities have been reported. Goldschmidt⁴ reports a man forty-one years of age, having severe intestinal bleeding, collapsed on one occasion, tumor mass palpable in lower abdomen. Operation revealed a tumor of the jejunum, the size of a man's two fists, arising from the anti-mesenteric border; the greater part of the highly vascularized mass lay in the free peritoneal cavity adherent to the urinary bladder. Histological examination disclosed a leiomyoma.

Our case (Case V) of leiomyoma of the jejunum had four sharp hæmorrhages, his first sufficient to produce immediate unconsciousness, while preaching from a pulpit.

The adenomata are common; single as a rule, sometimes multiple. Small, generally sessile, if pedunculated, they frequently are the cause of intussusception. They originate in the epithelium of the intestinal glands. Many are found in autopsy reports. We report two in our series; one (Case II) a small tumor, 2.5 by 3 by 2 centimetres, of the ileum producing an intussusception. The other (Case I) of the duodenum, 1 centimetre in diameter, sessile in type.

An unusually interesting group of tumors of the small intestine and appendix are the so-called argentaffin tumors formerly termed "carcinoids"; certain granules in their cells show a marked affinity for silver. Repeatedly confused with carcinomas, their exact nature is not thoroughly understood. They occur singly; often multiple, giving rise as a rule, to symptoms of acute or chronic ileus. Small, sessile or pedunculated, they grow slowly and metastasize rarely. In the appendix they are often overlooked when examined grossly, for they appear as minute nodules embedded in the mucosa. Masson⁵ discovered in 1928 that these tumors arose from the argentaffin cells of the intestine. Forbus⁶ reported six cases and called particular attention to the harmless character of these tumors.

On account of malignant degeneration of accessory pancreatic tissue, this group is of surgical importance. These rests occur in the stomach, duodenum, jejunum, ileum, folds of the mesentery and colon; and in the wall of the gall-bladder. The nodules, usually about 1 centimetre in diameter, contain pancreatic ducts, acini and islands of Langerhans. Intussusception may result, or bands of adhesions may form from the nodule to a neighboring loop of intestine causing an ileus.

Branham⁷ reports a pyloric growth involving the stomach wall, as well as the first portion of the duodenum. Pylorectomy. Dr. W. H. Welch diagnosed the tumor as cancer originating in aberrant pancreatic cells.

Recently Bookman⁸ reports another carcinoma of the duodenum secondary to pancreatic rests in the first portion of the duodenum, occurring in a young woman twenty-seven years of age. In our own series (Case VI) accessory pancreatic tissue was found in a woman of sixty-four, who had complained of pain in the right upper quadrant of the abdomen; the eating of meat increased the symptoms. A small, one-centimetre in diameter, elevated, rounded mass of accessory pancreatic tissue was found in the duodenum just to the right of the pyloric ring, which proved to be benign.

Hemangiomata are rarely found reported in the literature. Carmen⁹ in 1921 describes one just to the right of the pyloric ring; a sessile tumor 4 by 5 centimetres casting a rounded area of diminished density in the barium-filled duodenal cap suggesting a polyp.

In 1923 Waugh¹⁰ reported a case of congenital cyst of the duodenum in a baby nineteen days old.

Malignant tumors.—Carcinoma.—There are various forms of small intestinal cancer. Ewing¹¹ describes them as: First, part of a local or general intestinal polyposis. Second, multiple or single, embryonal carcinoid tumors; single or multiple usually in the jejunum or ileum. Third, localized adenocarcinomata; this latter type represents the majority of carcinomata of the small bowel. Of all neoplasms of the small intestine carcinoma is the one most frequently found; yet they comprise only 3 per cent. of cancers of the entire intestinal tract. Combining two reports from the Mayo Clinic, one by Judd,¹² in 1919, and another by Rankin and Mayo,¹³ in 1930, there are recorded fifty-five cases of malignancy in the small bowel; during this same

period of time, there were 4597 cases of carcinoma of the large intestine and rectum, and 4335 cases of cancer of the stomach. They occur more often in the duodenum and ileum than in the jejunum. Judd and others feel that carcinoma arising in the bed of an ulcer is uncommon. In the duodenum they are found more often in the middle portion, next in the first portion, and frequently in the third portion. In the third or infra-ampullary part, they usually form a constricting type of growth; and when the duodenum is markedly dilated, annular tumor in this segment should be suspected. In the jejunum and ileum they exist as an annular growth or as a fungoid tumor. Some invade the outer coats and develop free in the peritoneal cavity.

Metastasis is common in carcinoma of the small intestine, usually involving liver, lungs, mesentery and peritoneum.

Of our fifteen cases of small-bowel neoplasms, there were six carcinomata, five found at operation and one discovered at autopsy in a woman who died shortly after admission to the hospital, without operation. Two in the duodenum, one in the jejunum, three in the ileum.

Sarcoma.—Sarcoma of the small intestine is less frequently found than carcinoma. Generally they are single and usually found in the ileum. The spindle-cell type, generally small and pedunculated, is rare. If obstruction occurs, which is not often, it is "due to growths in the mesentery or to kinks or adhesions of the intestine."¹⁴ There are three types of sarcomas: (1)—A growth from the peritoneal surface of the bowel wall; exceedingly rare, likely to cause acute torsion of the bowel wall. They occasionally grow to be quite large. (2)—A small polypoid mass projecting into the lumen of the bowel; this is the most common type; many months of colicky pains, fever, cachexia and finally ileus due to intussusception. (3)—A flattened extensive infiltration of the wall of the intestine. Usually palpated in the abdomen as an appendiceal abscess, carcinoma of the colon, or a twisted ovarian cyst. Involvement of adjacent glands and metastatic dissemination are not constant sequelae. One (Case XV) of our patients was a boy four years of age, with a lympho-sarcoma of the ileum, the tumor mass measuring 5 by 7 centimetres. Another (Case XIV), a man, age not given, with a lympho-sarcoma of the ileum, causing intussusception, through the ileo-cæcal valve.

Liu¹⁵ classifies sarcomata under the general heading of lymphoid-cell or granulation-tissue tumors, along with lymphosarcoma and round-cell sarcoma; he includes also chronic inflammatory tumors, intestinal Hodgkin's disease, granulomatous pseudoleukæmia or lymphoblastoma. They are all round-cell tumors, arising from lymphoid nodules in the submucosa of the intestinal wall. Grossly they may have the appearance of a polyp or conform to the annular type. Their characteristic features histologically are: (1)—They are new growths composed of unusually large round cells in various shapes and sizes. (2)—Even larger cells containing two or three nuclei are found. (3)—Mitotic figures are common. (4)—The growths arise in the submucosa, invade the mucosa on one side and the muscularis on the other. Ulceration is not infrequent.

Symptoms and signs.—We realize that few deductions can be drawn from so small a number of cases. But from these and others reported we are convinced that early, accurate diagnosis depends upon a thorough evaluation of the earliest symptoms—those vague and mild complaints, present intermittently for months and even years, which the patient frequently considers insignificant.

Early symptoms are slight. It is with some difficulty that patients remember the mild colicky twinges or variations in the character of their stools after the onset of severe pain, genuine abdominal discomfort and loss of weight. In going back carefully through our case histories and in talking to patients after the operation, we have found that early symptoms were present, and in some instances, no doubt, if properly analyzed would have led to a timely and perhaps correct diagnosis. One patient (Case V) with the bleeding Myoma took some months after his recovery to recollect that two years preceding his first hæmorrhage, he had been treated for a so-called mucous colitis. Another (Case XI), with a carcinoma of the duodenum, for six years had taken huge doses of soda bicarbonate for indigestion. She and two members of her family denied that this could have been connected with her present severe pain, nausea and vomiting. Still another (Case XII) with an annular carcinoma of the terminal ileum producing chronic obstruction, was emphatic that her difficulty began two years previously, with attacks of pain at intervals of every six weeks, generally in the right lower quadrant accompanied by nausea and vomiting, yet her husband was equally emphatic that she had complained of lower abdominal distress for a full six months prior to her frank attacks.

The earliest symptoms are frequently indefinite and even the latter ones are difficult to classify until the diagnosis is fairly apparent, as when a mass is palpable, or the X-ray warns of an impending obstruction. In general, the symptoms depend upon the site of the neoplasm, whether intra- or extra-luminal; its size, whether annular, sessile or infiltrating; and to whether it be malignant or benign. To correctly analyze the symptoms seems of prime importance, for the X-rays although frequently helpful are not infallible and thus we must primarily depend upon accurate estimation of symptoms for early diagnosis.

Benign tumors give rise usually to symptoms which are different from those of malignant tumors. If the tumor is benign and small no symptoms will be complained of; the majority of such tumors are found accidentally at operation for another condition or at the autopsy table. Sometimes good-sized tumors on the serosal surface give no symptoms. Those benign tumors arising from the mucosa and projecting into the lumen, that are of good size, may produce severe hæmorrhage, intestinal obstruction and often intussusception. Of Raiford's eighty-two cases 37 per cent. gave symptoms sufficient to demand operation; 17 per cent. gave symptoms of such uncertain nature that they were not operated upon and the tumor was found at autopsy;

46 per cent. gave no symptoms and the growth was discovered accidentally at post-mortem.

Neoplasms of the duodenum cause symptoms different from those of the jejunum and ileum. In those of the duodenum the pain is usually in the epigastrium, easily confused with the pain associated with duodenal ulcer; if malignancy exists the pain is often constant; in the jejunum and ileum it is likely to be painless until intussusception or obstruction intervenes. Accompanying the severe, colicky pain of the impending obstruction, or the sharp, constant pain of intussusception, nausea is a frequent symptom, transient in the incipency of the disorder it goes hand in hand with so-called indigestion, heartburn and eructation. Nausea and vomiting were prominent symptoms in 50 per cent. of our cases, regardless of in which portion of the bowel the tumor was situated. Vomiting does not take place prominently until a benign, pedunculated growth or even a fungoid, malignant one incites a beginning intussusception; a constricting growth high up in the jejunum or in the duodenum causes early vomiting. Loss of weight was complained of in eight of our fifteen cases; pronounced in the malignant growths, it was accompanied by anæmia and cachexia. Blood in the stools occurs not until late, usually after ulceration has taken place. Bleeding varies from small amounts not constantly detected to massive hæmorrhages, sufficient to almost totally incapacitate. It may be the only symptom of the disease, as in our case (Case V). Jaundice is suggestive in those cases occurring in the ampullary segment of the duodenum. It occurred in one instance in our series where the growth was proximal to the ampulla, yet coexisting œdema was sufficient to close the infraduodenal portion of the common bile-duct. Increased peritoneal fluid is a sign to be watched for where malignancy is suspected. "Cancer of the ileum gives rise to no signs which render the localization of the disease a matter of certainty."¹⁶

It seems purposeful to emphasize vague abdominal discomfort in a person of any age, who tires easily, with loss of appetite, loss of weight, whose bowels are irregular, either becoming increasingly constipated or alternating attacks of diarrhœa and constipation.

Röntgenography.—Repeated X-ray examinations considered with the clinical findings sometimes prove a valuable aid in diagnosis. It must be emphasized that negative findings do not exclude the presence of a tumor. In our patient with the leiomyoma of the jejunum, who almost had a fatal outcome from severe hæmorrhages, repeated complete gastro-intestinal series, four in all, failed to show anything, except in the last series we held tenaciously to a constant defect in the second portion of the duodenum, which was diagnosed a bleeding diverticulum; when we located the myoma well down in the jejunum we then knew how pitifully we had clung to an artefact.

The X-ray diagnosis of tumors of the duodenum is difficult, for the barium proceeds rapidly through the duodenum; unless the tumor is of large size, it is seldom visualized; however, if a "vacuole" is constant in the bulb

the presence of a tumor originating in the duodenum is suggested; however, if there is an accompanying six-hour gastric retention, a growth arising in the stomach and prolapsing into the duodenum must be excluded.

Pre-operative diagnosis of tumors, that of the jejunum and ileum, by röntgenographic methods is even more difficult than that of the duodenum. Generally it fails to prove the presence of a tumor and can only be of assistance by demonstrating a localized narrowing of the lumen or portraying shadows pathognomonic of obstruction. Plates taken with the patient in the erect posture is universally practised, in attempting to locate these tumors.

The reason for so few X-ray reports in our cases, is, no doubt, due to the fact that many necessitated immediate surgery, or if not operated upon almost at once, impending obstruction ruled out this diagnostic aid.

Treatment.—It is agreed that all tumors of the small intestine should be managed surgically. When there is no obstruction present, resection with end-to-end suture or lateral anastomosis according to the individual surgeon's liking and ability is indicated. Should even a mild degree of obstruction be present, a side tracking two-stage procedure is sometimes wise; for, as has been repeatedly shown, a one-stage operation has proven hazardous. Especially is this true in the terminal ileum. The jejunum offers the most accessible and least dangerous portion of the small bowel to be resected.

At operation syphilitic strictures or nodules which are secondary to growths of some other viscera may prove confusing. It is impossible at times to differentiate between a tuberculous and a cancerous lesion. Numerous incidences are recorded where definite inflammatory lesions of the small bowel at operation could not be differentiated from new growths. If the slightest doubt exists resection is justified.

In our group eight primary resections were done with five side-to-side anastomoses, and three end-to-end sutures. One local excision of an adenoma of the duodenum; one local excision of a pancreatic rest; one ileo-colostomy succumbed the fifth day post-operative; one anterior gastroenterostomy with a Murphy button, short-circuiting an advanced carcinoma of the jejunum. One posterior gastroenterostomy for annular growth of second portion of duodenum. One exploratory celiotomy.

Prognosis.—The prognosis is particularly unfavorable in malignancy of the small bowel. It is less favorable than following operation for cancer of the stomach and large intestine. In the benign group the prognosis is good. It is a fact that whether young or old, a patient with a malignant tumor of the small intestine lives only a few years even though an apparently early and complete resection has been done.

Results.—Of the fifteen patients operated upon, five died within eight days after operation; a high operative mortality.

In those patients with benign tumors of the intestine our results were excellent, except for the case of chronic ulcerative granuloma who died at his home one month later from lobar pneumonia. The patient with the

bleeding leiomyoma of the jejunum made a splendid recovery, was seen one month ago, has gained tremendously in weight, is active and in excellent condition.

Of the six carcinoma cases: One died of shock seven hours post-operative; one died sixteen hours after admission to the hospital without operation. One died on the third day post-operative, of peritonitis. In this case there were multiple carcinomata in the last four feet of the terminal ileum; ileocolostomy proved unsuccessful. One died on the eighth day post-operative, of peritonitis. With this patient, I believe the two-stage procedure would have ended differently, as she was partially obstructed. Another patient with a constricting duodenum above the ampulla died three months after gastroenterostomy had been performed; inanition, anæmia, liver metastasis were the autopsy findings in this case. Our one case of Hodgkin's disease of the intestine died two months after being discharged from the hospital, probably a metastatic death. Of our two cases of sarcoma of the ileum, one died nine hours post-operative, of shock; this patient was partially obstructed at the time of admission; immediate resection with end-to-end suture was attempted. The other case of sarcoma of the terminal ileum with an intussusception was discharged from the hospital improved. This patient probably died shortly afterwards.

Four of our operative cases that died within eight days after operation entered the hospital with either partial or complete obstruction.

CONCLUSIONS

(1) Tumors of the small intestine are of sufficient rarity to warrant reporting of cases.

(2) They occur at any age; more common in males than in females.

(3) Intraluminal benign tumors frequently cause intussusception.

(4) Accurate diagnosis depends upon sound evaluation of the earliest symptoms—those often considered insignificant by the patient. Röntgenography is rapidly becoming a more reliable and dependable aid in localizing these tumors.

(5) Poorly formed bowel movement, malaise, unusual intermittent twinges in the abdomen are frequently the earliest symptoms.

(6) Those tumors that bleed produce a marked secondary anæmia; at times sharp hæmorrhages may incapacitate; occasionally prove fatal.

(7) Any easily movable mass in the abdomen should be early eliminated as a tumor of the small bowel.

(8) Immediate resection with removal of gland-bearing area is indicated, unless obstruction is present; then a two-stage procedure is preferable.

(9) Four of our operative cases that died within eight days after operation entered the hospital with either a partial or complete obstruction.

(10) In benign tumors the prognosis is good. It is particularly unfavorable in the malignant group.

TUMORS OF SMALL INTESTINE

RÉSUMÉ OF OUR FIFTEEN CASE HISTORIES

CASE I.—(R. H. No. B 1326, Path. No. not given.) Date of operation, February 2, 1911. A man (age not stated) complaining of constant dull pain in epigastrium and right hypochondrium for a period of three months. Other than complaint, nothing of



FIG. 1.—Case II. Specimen of a portion of the ileum measuring 20 by 5 by 5 centimetres arrows indicating a small intra-luminal adenoma measuring 2.5 by 3 by 2 centimetres, which was the cause of the intussusception.

importance in history. *Physical examination.*—Negative. (No report of X-ray having been taken.) *Pre-operative diagnosis.*—Duodenal ulcer or cholecystitis. *Operation.*—Local excision of tumor. *Diagnosis.*—Adenoma of duodenum (anterior wall.) *Patho-*

logical report.—Specimen consists of tissue 1 centimetre in diameter. One surface covered entirely with mucous membrane showing an area of ulceration. Beneath muscularis mucosa a considerable mass of gland tissue forming an adenoma. *Microscopic diagnosis.*—Adenoma of duodenum.

CASE II.—(R. H. No. A 19311, Path. No. S.B. 195.) Date of operation, March 31, 1922. A man, aged twenty-seven years, complaining of attacks of severe epigastric pain; duration six months. Recently had had attacks of nausea and vomiting, alternating attacks of constipation and diarrhoea, malaise and abdominal distention. Stool poorly



FIG. 2.—Case III. Ninety-two centimetres of resected small intestine with a fibroma measuring 2.5 centimetres in diameter, indicated by arrow.

formed, occult blood. *Physical examination.*—Abdominal distention and visible peristalsis. No X-rays taken. *Pre-operative diagnosis.*—Partial intestinal obstruction due to adhesions (appendicectomy, 1910). *Operation.*—Resection. Side-to-side anastomosis. *Diagnosis.*—Adenoma of ileum (intussusception). *Recall.*—Seven months after operation. In excellent health. Bowels regular; gain in weight. *Pathological report.*—The specimen (Fig. 1) of an intussuscepted portion of ileum measuring 20 by 5 by 5 centimetres; its upper half presents a normal serous coat while the distal portion is gangrenous in appearance. When opened the mucosa shows corresponding changes in its gross

TUMORS OF SMALL INTESTINE

appearance. At the apex of the discolored, intussuscepted bowel is a small tumor measuring 2.5 by 3 by 2 centimetres, definitely encapsulated, firm in consistency and arising from the mucosa by a definite pedicle, so that the tumor mass swings freely within the lumen. *Microscopic diagnosis*.—Adenoma of ileum. Gangrene of small intestine due to intussusception.

CASE III.—(R. H. No. A 2003, Path. No. S.B. 7336.) Date of operation, September 8, 1911. No history attached to chart. Patient obviously operated upon shortly after admission to the hospital. (Probably with signs and symptoms of intestinal obstruction.) *Operation*.—Resection. End-to-end suture with Murphy button. *Diagnosis*.—Fibroma of ileum (intussusception). *Discharged*.—Cured. No follow-up report. *Pathological report*.—Specimen (Fig. 2) consists of 92 centimetres of resected small intestine, 55 centimetres of which is bluish black and looks gangrenous. An area of intussusception which measures 16 centimetres has been opened. Occupying the intestinal lumen at the extreme resected end, there is an encapsulated, pedunculated gland which feels firm and elastic (almost like a small, hard rubber ball), which measures $2\frac{1}{2}$ centimetres in diameter and is covered by a black, warty looking membrane which peels off easily and exposes a whitish mass of tissue containing blood-vessels on the surface. (On account of the fibroma being a rare tumor it was thought advisable to include a detailed microscopic examination.) *Microscopic examination*.—Tumor is composed of white fibrous tissue containing many blood-vessels and capillaries. Covering one surface of the section there is a very vascular layer of tissue, which is infiltrated with leucocytes, and lies on a fibrous basement membrane. *Microscopic diagnosis*.—Simple fibroma.

CASE IV.—(R. H. No. B 8564, Path. No. S.A. 1646.) Date of operation, November 29, 1916. A man, aged thirty-one years, complaining of hypogastric pain, alternating attacks of constipation and diarrhoea, nausea and vomiting, abdominal distention, malaise and + + + loss of weight. Duration three and one-half months. *Physical examination*.—Revealed visible peristalsis, abdominal distention, palpable mass, ascites, succussion splash, secondary anaemia. X-ray report lost. *Pre-operative diagnosis*.—Neoplasm of colon below splenic flexure. *Operation*.—Resection; side-to-side anastomosis. *Diagnosis*.—Chronic ulcerative infective granuloma. *Result*.—Died one month later, at home, of lobar pneumonia. *Pathological report*.—Specimen (Fig. 3) consists of a portion of small intestine measuring 23 centimetres in length and having an average diameter of 5 centimetres. This has been evaginated so that the lumen is exposed throughout. The mucosa is of a reddish-brown hue and has lost practically all of its normal corrugations. The special pathological features are several elongated hyperplastic ulcerated areas arranged in pell-mell manner and running the direction of the circumference. The lower 4 centimetres of the specimen is entirely involved in the process similar to these ulcerations which appear as a large fungoid bulb-like expansion. *Microscopic diagnosis*.—Chronic ulcerative infective granuloma.

CASE V.—(Leroy H. No. 2201, Path. No. [R. H.] S.C. 5140.) Date of operation, May 11, 1931. A man, aged forty-three years, complaint: collapse, severe intestinal hæmorrhages, malaise of two months' duration. Two years previously had had vague abdominal discomfort, treated for colitis. A chief complaint was that for two years bowel movements had been irregular, not free and of relatively small calibre. No pain in abdomen, no tenderness on palpation. Large amount of blood in stools. Seventeen blood counts taken before operation—average red blood cells 3,275,000; average hæmoglobin 66.7 per cent. Four blood transfusions before operation. Four complete gastro-intestinal X-ray series taken—all negative. *Pre-operative diagnosis*.—Bleeding diverticulum of duodenum. *Operation*.—Resection. Side-to-side anastomosis. *Diagnosis*.—Leiomyoma of jejunum. (Approximately 10 inches from duodeno-jejunal junction.) *Follow-up note*.—March 1, 1932, excellent health. Completely cured. *Pathological report*.—Section of intestine is 7 centimetres in length; 3 centimetres in diameter; contains at its centre within the wall a firm but not stony hard tumor $2\frac{1}{2}$ centimetres in diameter

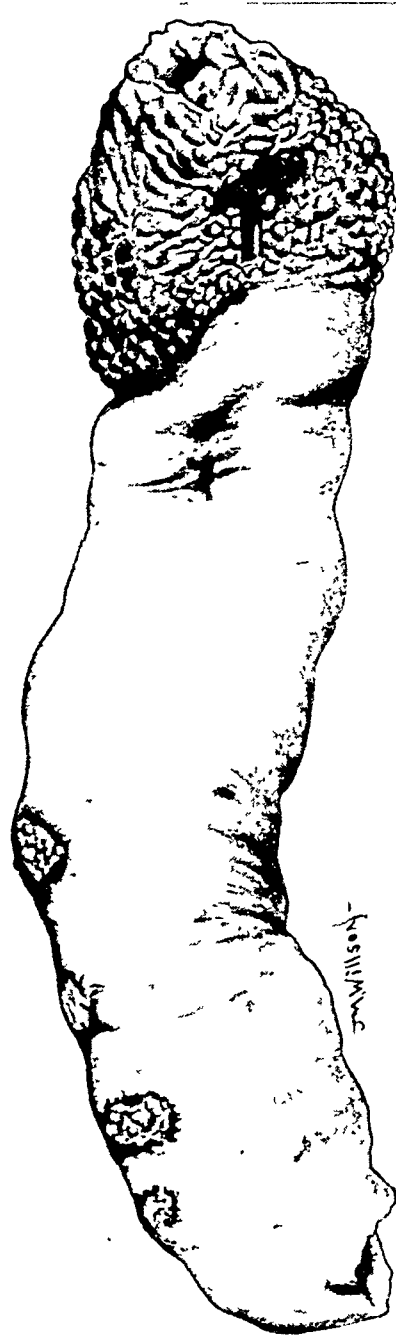


FIG 3.—Case IV. Portion of the terminal ileum measuring 25 centimetres in length with an average diameter of 5 centimetres, evaginated so that the lumen is exposed throughout. Hyperplastic ulcerated areas are running in the direct on of the circumference, the lower 4 centimetres of the specimen have a hyperplastic ulcerated area which appears as a large fungoid, bulb-like expansion.

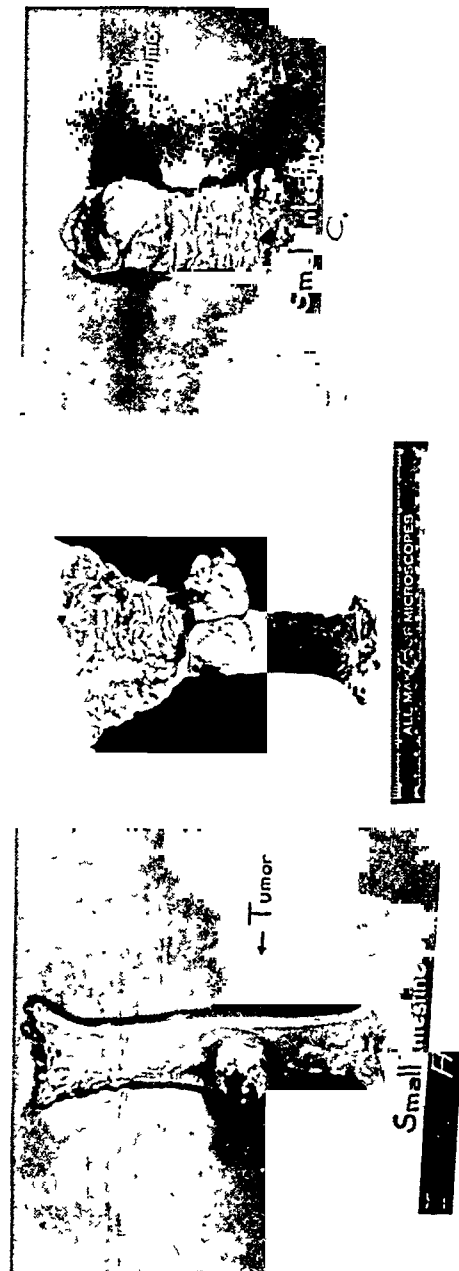


FIG. 4 —Case V. A Myoma protruding from serosal surface of the jejunum. B Cross-section of tumor mass. C Mucosal surface of tumor.

TUMORS OF SMALL INTESTINE

which projects from the side of the intestine. (Fig. 4.) It is roughly circular but it has at its tip two small globular projections, each about 1 centimetre in diameter, one of which is very hæmorrhagic in appearance. In general, however, the tumor is grayish-white in color. Upon inverting the intestine the tumor is found to be practically submucosal; the mucosa overlying it presents a tiny split, probably of recent origin. *Microscopic diagnosis*.—Leiomyoma of small intestine. (Benign.)

CASE VI.—(R. H. No. 24699, Path. No. S.B. 9139.) Date of operation, October 17, 1929. A woman of forty-four years of age, complaining of oppression and uneasiness in right upper quadrant of abdomen. Pain at times radiating towards the left. Eating of meat increases symptoms. Other than a life-long constipation, no other history. Slight tenderness on palpation in epigastrium. *X-rays*.—Negative. *Pre-operative diagnosis*.—Chronic cholecystitis. *Operation*.—Excision of aberrant pancreatic tissue tumor from anterior wall of duodenum. *Diagnosis*.—Aberrant pancreatic tissue tumor of duodenum. *Follow-up note*.—Five-year complete cure of symptoms. *Pathological report*.—The portion of the duodenal wall is 1 centimetre in diameter and $\frac{3}{4}$ centimetre in thickness. The mucosa is smooth. The serosa appears somewhat roughened. *Microscopic diagnosis*.—Aberrant pancreatic tissue in duodenum. Diagnosis confirmed by Doctor Ewing.

CASE VII.—(R. H. No. A 3296, Path. No. not given.) Date of operation, November 26, 1912. A man, aged forty-two years, complaint three months' duration; colicky pains in upper abdomen, beginning on left side and passing over to right side. Onset one hour after meals; gurgling sounds heard and a mass forms in left upper quadrant. Constipation, no diarrhoea. Vomited blood. Distention upper abdomen; + + + + loss of weight. Marked secondary anæmia. Anterior gastroenterostomy with Murphy button. *Diagnosis*.—Carcinoma of jejunum. *Result*.—Discharged from hospital. Improved. (Probably died.)

CASE VIII.—(R. H. No. B 5527, Path. No. B 9374.) Date of operation, July 6, 1914. A male (age not given) complaining of upper abdominal pain with indigestion for six months and loss of weight, jaundiced, tenderness in upper abdomen. *First operation*.—February 11, 1914. Appendicectomy. Division of Lane kink. *Second operation*.—July 6, 1914. Cholecystenterostomy. *Third operation*.—October 20, 1914. Posterior gastroenterostomy. *Diagnosis*.—Carcinoma of the duodenum. *Result*.—Died, January 23, 1915. Inanition. Anæmia. Liver metastasis. *Autopsy report*.—The pylorus is seen to be patent. About $3\frac{1}{2}$ inches from pylorus there is a very firm annular constriction of the duodenum which has an opening about the bore of a lead pencil. On section this cuts with resistance, and has a fibrous, almost cartilaginous consistency. This lesion is rather sharply demarcated and the mucosa on either side is hyperplastic and congested. The papilla of Vater is about 1 centimetre beyond the constriction. *Microscopic diagnosis*.—Primary adenocarcinoma of duodenum with metastasis to liver. Chronic diffuse pancreatitis. Moderate chronic diffuse nephritis. Chronic inflammation of primary growth in duodenum.

CASE IX.—(R. H. No. B 14107, Path. No. 8760.) Date of operation, April 9, 1921. A woman (age not given); complaint four months' duration, abdominal pain and increasing constipation. Abdominal distention; malaise; —loss of weight. *X-ray report*.—Negative for growth but stasis in the small intestine. *Pre-operative diagnosis*.—Intestinal neoplasm. (Large or small bowel not stated.) *Operation*.—Resection. End-to-end suture. *Diagnosis*.—Carcinoma of ileum. *Result*.—Died, seven hours after operation, of shock. *Pathological report*.—The new growth (Fig. 5) is oval in shape and in size 5 by 6.5 centimetres with a deep ulcerating area 1 by 2.5 centimetres which was perforated at operation. The main portion of the growth is at the site of attachment of the mesentery and almost obliterates the lumen. Atypical acini and epithelial cells growing at will and infiltrating the duct wall. The cells are in various bizarre arrangements, many retaining the acini formation and many breaking through the limiting basement membrane to invade lawlessly in groups or strands the tissue surrounding. The cells vary in

staining quality and some of their nuclei show mitotic figures. *Diagnosis*.—Adenocarcinoma of ileum.

CASE X.—(R. H. No. 21664, Path. No. 5658.) Date of operation, November 16, 1925. A woman, aged fifty-seven years; complaint epigastric pain, attacks of nausea and vomiting, alternating constipation and diarrhoea and distention; duration six months. Considerable malaise, — — — loss of weight, palpable mass, ascites, secondary anaemia, gastric analysis normal. *X-ray*.—Large rounded mass right lower quadrant of abdomen. *Pre-operative diagnosis*.—Carcinoma of stomach. *Operation*.—Ileo-colostomy. Specimen of tissue removed from surface of neoplasm. *Diagnosis*.—Carcinoma (multiple) in last four feet of ileum. *Pathological report*.—Specimen consists of two irregular-shaped pieces of tissue measuring 2 by 4 by 1 centimetre and 2 by 3 by 5 centimetres in their greatest diameter. They are firm in consistency and their cut surfaces present a hard, grayish-white appearance. *Result*.—Died three days post-operative, of peritonitis. *Micro-*

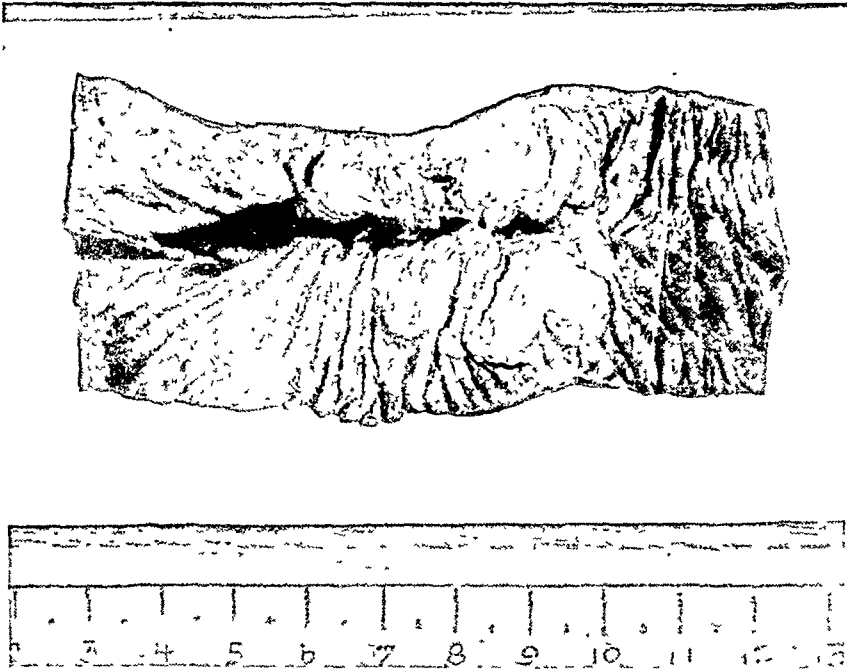


FIG. 5.—Case IX. Carcinoma of the ileum, the neoplasm oval in shape, measuring 5 by 6.5 centimetres, with a deep ulcerating area in the centre measuring 1 by 2.5 centimetres.

scopic diagnosis.—Metastatic adenocarcinoma of omentum, probably of intestinal origin.

CASE XI.—(R. H. No. B 29456.) (Autopsy series 1931, No. 16.) Date of autopsy, February 16, 1931. A woman, aged seventy-one years; complaint; duration one week of abdominal pain and distress, nausea and vomiting, malaise for some months. Questioning members of her family revealed that for the past eight or nine years patient had been troubled with severe attacks of "indigestion." Huge doses of soda bicarbonate usually brought relief. *No X-ray report*. *Diagnosis*.—Intestinal obstruction. Cause unknown. *Result*.—Died sixteen hours after admission. *Autopsy report*.—On the inferior aspect of the first part of the duodenum (Fig. 6) there is seen a perforation of triangular form about 1 centimetre in length with red, pouting margin. The pyloric ring is found sharply defined and the mucous membrane on the gastric side is everywhere intact. On the duodenal side the perforation with engorged edges is found 4 centimetres below the pylorus. The mucosa is somewhat gray and papillary, but most of the thickening of the wall is in the deeper layers. Attached to the neighboring serosa are several lymph nodes, the largest 3 centimetres in diameter. *Microscopic diagnosis*.—Adenocarcinoma of duodenum with necrosis and perforation. Metastasis to regional lymph nodes.

TUMORS OF SMALL INTESTINE

CASE XII.—(R. H. No. B 26912, Path. No. 4830.) Date of operation, November 14, 1931. A woman, aged thirty-nine years, complaint: duration three weeks. Abdominal pain and distress, nausea and vomiting. Alternating attacks of constipation, diarrhoea. Malaise; abdominal distention; + + + loss of weight. Visible peristalsis and tenderness over the abdomen, — blood in stools; the faecal movements themselves were poorly formed. Ascites. *X-rays*.—Showed distended loops of small bowel. Point of obstruction not identified. Appendix removed seven years ago. Members of family maintain that for past two years patient has had attacks of pain about every six weeks, generally in the right lower quadrant of abdomen accompanied by nausea and vomiting. For three weeks previous to operation the patient had been treated by family physician for tuberculous peritonitis. *Pre-operative diagnosis*.—Partial intestinal obstruction, due to adhesions in the terminal ileum. *Operation*.—Resection terminal ileum and ascending colon. Side-to-side anastomosis. Enterostomy (Witzel-Mayo) 10 inches above site of

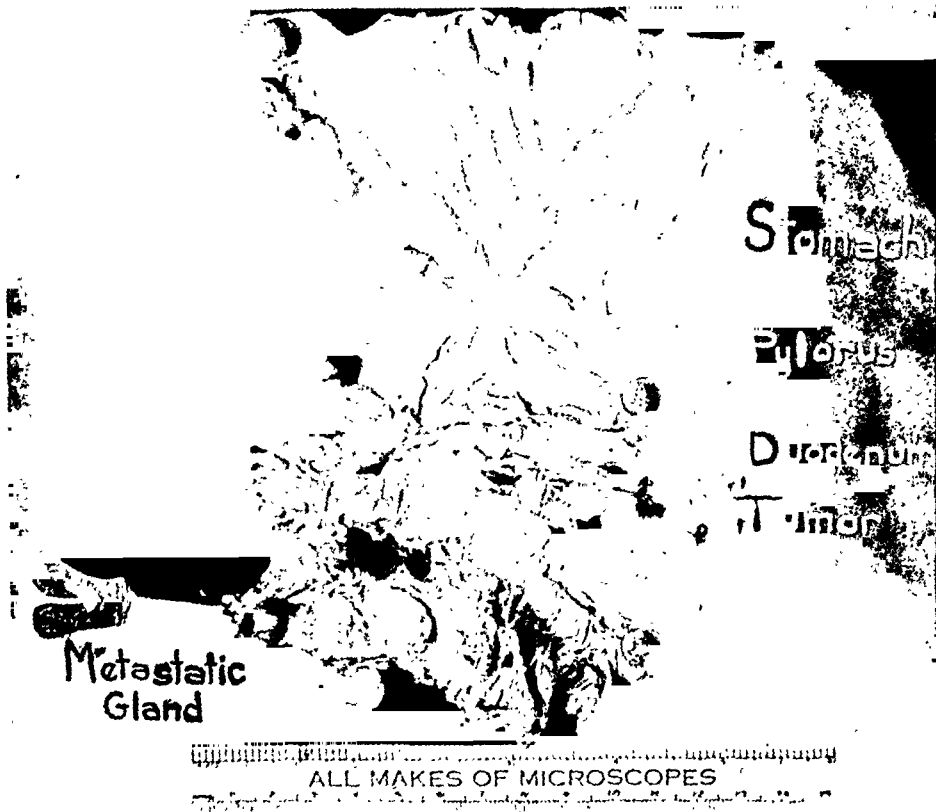


FIG. 6.—Case XI. Carcinoma of the duodenum indicated by the upper grooved director. The lower grooved director points to a large metastatic lymph-node measuring 3 centimetres in diameter.

anastomosis. *Result*.—Died eighth day post-operative, of peritonitis. (On account of even partial obstruction a two-stage procedure would have been a wiser plan.) *Pathological report*.—Specimen consists of the cæcum, measuring about 16 centimetres, and the terminal ileum, measuring 8 centimetres. On the serous surface the centre of the ileum shows a definite constriction pinching in the bowel wall at a distance 4.5 centimetres from the ileo-cæcal junction. On opening the bowel there is found in the ileum a soft, papillary, sessile mass which encircles the lumen; has rolled edges and a central ulceration. The total length is 4 centimetres; average thickness is 1.2 centimetres. On section the entire thickness of the intestinal wall is involved. Beyond the tumor the ileum is distinguishable and has a normal mucosa for its terminal 3 centimetres. A lymph node removed from the mesentery consists of a fatty mass 3.5 by 1.5 by 2 centimetres. On section grayish-white hard nodules are seen within this. *Microscopic diag-*

nosis.—Adenocarcinoma of ileum, Grade III, with metastases to lymph node of mesentery.

CASE XIII.—(R. H. No. B 25225, Path. No. S.B. 9869.) Date of operation, February 23, 1928. A male, aged fifty-four years, complaining of severe abdominal pain, cramp-like in region of umbilicus, relieved frequently by bowel movements. Intense desire to defecate frequently. Duration of symptoms one month; — loss of weight. *X-rays*.—Irregular filling of the small bowel, dilatation and gas, distention of loops of ileum. *Pre-operative diagnosis*.—Carcinoma of colon. *Operation*.—Exploratory celiotomy. Removal of lymph node for diagnosis. There were two areas in the small intestine, about 8 inches apart on the anti-mesenteric surface, the distal one the size of a silver quarter, about 1½ inches thick, with a nipple-like projection on the serosal side. On cæcum a pedunculated mass the size of a man's fist. Enlarged mesenteric lymph nodes. *Diagnosis*.—Undetermined at operation. *Pathological report*.—Specimen consists of a lymph node 1 centimetre in diameter. Capsule is intact. On section what seems to be a layer of normal lymphoid tissue ¼ centimetre in thickness surrounds a white, homogeneous friable centre. Dense fibrous capsule within which is a dense cellular mass largely composed of reticulo-endothelial cells among which are scattered lymphocytes. Cells poorly stained, frequently contain pale vesicular nuclei. Many giant cells are present with single or multiple pale nuclei. Cytoplasm granular and stains poorly. Mitosis is a rather common occurrence. No eosinophiles seen. *Microscopic diagnosis*.—Intestinal Hodgkin's disease.

CASE XIV.—(R. H. No. A 780, Path. No. 3482.) Date of operation, August 13, 1910. A man (age not given), complaint, duration three weeks. Abdominal pain accompanied by "marked gurgling noises," no nausea or vomiting, + + loss of weight. *Operation*.—Resection. Side-to-side anastomosis. *Diagnosis*.—Sarcoma of terminal ileum (intussusception). *Result*.—Discharged improved. No recall. *Pathological report*.—Erosion of mucous membrane with superficial necrosis and inflammation. Depths of tumor made of small round cells extending to muscular layer and invading it to a certain extent. *Microscopic diagnosis*.—Round-cell lymphosarcoma, neighboring glands show involvement.

CASE XV.—(R. H. No. A 26965, Path. No. S.B. 8601.) Date of operation, June 18, 1927. A boy, four years of age, complaining of acute pain in abdomen, malaise, attacks of nausea and vomiting and + loss of weight. Duration four months. Parents state prior to present illness, patient had begun to "lose in general health" with appetite poor and color pale. *Pre-operative diagnosis*.—Intussusception. *Operation*.—Resection. End-to-End suture. *Diagnosis*.—Sarcoma of ileum. *Result*.—Died nine hours following operation, from shock. *Pathological report*.—Specimen consists of 30 to 40 centimetres of small intestine near the centre of which there is an oval mass measuring 5 by 7 centimetres. The tumor mass was formed by thickening of the gut wall. Several yellow, necrotic areas on surface of the tumor. On section of the tumor, mass found to be largely necrotic. Lumen is dilated; lined with necrotic mucosa; and filled with bloody faecal matter. Total weight of whole mass is 275 grams. *Microscopic diagnosis*.—Lymphosarcoma of ileum.

BIBLIOGRAPHY

- ¹ Raiford, T. S.: Radiology, vol. xvi, No. 2, p. 253, February, 1931.
- ² Mallory, F. B.: ANNALS OF SURGERY, vol. xciii, p. 1192, June, 1931.
- ³ Patterson, K.: Personal communication, 1929.
- ⁴ Goldschmidt, W.: Deutsch. Ztschr. f. Chir., Leipzig, Pp. 178–128, March 30, 1923.
- ⁵ Masson, P.: Am. Jour. Path., vol. iv, p. 181, 1928.
- ⁶ Forbus, W. D.: Bull. of Johns Hopkins Hosp., vol. xxxvii, p. 130, 1925.
- ⁷ Branham: Maryland Med. Jour., April, 1908.
- ⁸ Bookman, M. R.: ANNALS OF SURGERY, vol. xcv, No. 3, p. 464, March, 1932.

TUMORS OF SMALL INTESTINE

- ⁹ Carmen, R.D.: Amer. Jour. Roentgenol., vol. viii, pp. 481-482, 1921.
- ¹⁰ Waugh, O. S.: Surg., Gynec., and Obstet., vol. xxxviii, pp. 785-787, 1923.
- ¹¹ Ewing, James: Neoplastic Disease, W. B. Saunders and Co., Philadelphia.
- ¹² Judd, E. S.: Lancet, vol. xxxiv, p. 150, 1919.
- ¹³ Rankin, F. W., and Mayo, C. H., 2nd: Surg., Gynec., and Obstet., vol. 1, p. 939, 1930.
- ¹⁴ Douglas, John: ANNALS OF SURGERY, vol. lxxvi, p. 665.
- ¹⁵ Liu, J. Heng: Arch. Surg., vol. ii, pp. 602-618, October, 1925.
- ¹⁶ Bland-Sutton: Brit. Med. Jour., vol. i, p. 644, 1929.

LATE RESULTS IN THE OPERATIVE TREATMENT OF CARCINOMA OF THE BREAST*

BY PERCY KLINGENSTEIN, M.D.

OF NEW YORK, N. Y.

FROM THE SURGICAL SERVICE OF THE MOUNT SINAI HOSPITAL

THE results of our efforts, in behalf of the patient suffering from cancer, whether this be by surgery, radiotherapy, or a combination of both, should be surveyed from time to time, either to check the undue optimism which an occasional brilliant result will engender, or, on the other hand, to stifle the pessimism which has lately gripped the profession, as the result of a more complete follow-up of our patients. It is well known that clinical judgments based upon supposition are prone to be fallacious, and it is only by the systematic study of a group of cases, followed over a sufficiently long period of time, that we can arrive at a true estimate of the efficacy of our treatment.

Cancer of the breast lends itself particularly to this analysis. The lesion is usually superficially situated, the diagnosis readily established clinically or by operation and microscopical examination of the removed tissue, and the results of our therapy readily ascertainable by superficial palpation of the operative field, or by X-ray diagnosis of chest and bones where metastases most frequently manifest themselves. (Cartnett,¹ Lenz².)

Since the work of Halsted and Willy Meyer, the operation, with minor modifications only of incision and skin excision (Jennings³), has become standardized, so that changes in technic cannot be held to account for differences in the end-results in any of the yearly groups to be reviewed. In this series, the Halsted incision, with removal of both pectoral muscles, was used exclusively, although, at present, a number of surgeons are using the transverse or Stewart incision.

The advent of X-ray and radium therapy, in combination with surgery, has necessitated taking these added therapeutic factors into account in an analysis of results. Numerous other factors must enter here, *viz.*, the duration of the disease, its extent, the age of the patient, the biological characteristics of the neoplasm. It is almost impossible to evaluate all these factors in any given patient, nor have I attempted to do so in all these particulars, although a few of the above considerations will be discussed under prognosis, as determined by the follow-up. I have merely attempted, in so far as possible, to present a cross-section of the breast-cancer material admitted to a general hospital with particular reference to the results obtained with our therapeutic efforts.

For this purpose, I have taken the cases of breast cancer admitted to the general surgical service of the Mount Sinai Hospital from the years

* Read before the New York Surgical Society, February 24, 1932.

1922 inclusive of 1926, reviewing only those cases considered as operative and in which a radical mastectomy was done, without regard to the extent of the disease, its duration or other factors which will be seen to influence prognosis. It will be noted that the period of elapsed time since operation in the most recent cases will have been at least five years.

The author, in collaboration with Drs. A. V. Moschcowitz and R. Colp,⁴ undertook a similar study in 1926, and the results obtained in this series will be compared with this later group in an attempt to establish whether the results of our therapeutic efforts have improved.

This report comprises a study of fifty-seven cases of breast cancer, all of which were operated upon radically. There were fifty-nine operations, two of the patients returning subsequently with carcinomata in the remaining breast which necessitated mastectomy. No case is included in which the diagnosis was not confirmed by pathological examination of the tumor. Of these fifty-seven patients, two died as the direct result of operation—the first of these from infection, the second from a cerebral accident ten days post-operatively.

Sex.—There was one male patient in this series. His history dated back twelve years prior to admission seeking surgical relief only for a small ulcerating carcinoma near the nipple without lymph-node involvement. He died of distant metastases three years after operation. It would seem as if operation had disseminated a relatively benign form of growth.

Age.—Of the fifty-seven cases, one was below the age of twenty; two were in the second decade; eleven between thirty-one and forty; twenty-three between forty-one and fifty; thirteen between fifty-one and sixty; and seven between sixty-one and seventy-one. The influence of age upon prognosis will be discussed under follow-up.

Follow-up.—Of the fifty-seven patients admitted during the years 1922 and inclusive of 1926, two died in the hospital, following operation, leaving fifty-five patients whom it was possible to follow. Of this number, we obtained follow-up results of sufficient length of time to be of value in forty-two, or almost 75 per cent. of the cases; in two instances patients were lost track of by moving to different communities, in one after a follow-up of four years. Patients lost to follow-up are classified as dead of cancer and are tabulated as having died in the first year.

Of the thirteen patients operated upon in 1922 we have been able to follow and ascertain the end-results in eight. In four of these patients we have no follow-up data of any kind. One was lost track of in 1924, receiving X-ray therapy at St. Luke's Hospital, where there was no evidence of recurrence at that time, but the follow-up period is too short to be of value. Six of these patients have died; five of carcinoma, one of an intercurrent hemiplegia about six months ago, who, after her most recent follow-up, showed no evidence of any recurrence. One patient is alive and well; she has received no form of therapy since operation. One patient is living but is under treatment at Montefiore Hospital for metastases of her lung, skull and femur.

The average duration of life of the five patients who died with known carcinoma was three years.

Summary.—Of thirteen patients operated upon ten years ago, two are living, one of these with advanced recurrent disease. One patient died of an intercurrent disease apparently free of carcinoma nine years after operation. Over a ten-year period, including this last patient, 15 per cent. of the patients can be estimated to have been relieved of their disease.

Of the patients operated upon in 1923, totaling seven, four have died of carcinoma, the other three cases have been lost sight of. The average duration of life of those who were followed was slightly less than two years.

Of the nine patients operated upon in 1924, two are alive and well; one patient was not followed; of the six patients who died, one of these died in the hospital. Of the other five, one died six years after operation. The average duration of life after operation of those succumbing to the disease was three years.

In 1925, eleven patients were operated upon. All these patients were followed. Seven of these have died. Four patients are alive and well.

In 1926, eighteen patients were operated upon. Three patients were lost to follow-up. One patient was followed for three years and then moved to Canada. Up to that time she was free of recurrence. Five of this group are now living and well when last seen, no case being heard from or observed more than three months prior to this writing. Nine of these patients have died.

Summarizing the results of this follow-up (Table I) we find that twelve of a total of fifty-seven operated cases are alive and well for at least a period of five years. One patient who is not included in this number died of an intercurrent disease a few months ago, who had lived ten years, free of recurrence, before her death. If she were included, thirteen, or about 23 per cent., of the patients in this series would be alive and well for at least a period of five years. Of this number one would be living ten years, two for a period of eight years, four for a period of seven years, and five for a period of six or five years, depending upon how late in the year 1926 they were operated upon.

A number of patients in this series have lived more than five years, eventually succumbing to their disease, or are now alive but suffering from recurrences. These patients are classified as dead of cancer. Of the patients operated upon ten years ago, one is still alive and one lived for a period of six years after operation; three patients have lived for a four-year period; the others succumbed at varying intervals, the average being about two and a half years.

Lymph-nodes were involved with cancer in 72 per cent. of this group. Of the patients who are now living and well, about one-half were free of lymph-node involvement at the time of operation. Of the total number of patients free of lymph-node involvement, 40 per cent. have survived the five-year period; on the other hand, of those patients presenting themselves with

CARCINOMA OF BREAST

TABLE I

Year	No. of Pts.	1 yr. Died	2 yrs. Living	3 yrs. D. L.	4 yrs. D. L.	5 yrs. D. L.	6 yrs. D. L.	7 yrs. D. L.	8 yrs. D. L.	9 yrs. D. L.	10 yrs. D. L.										
1922.....	13	4	9	5	8	6	7	9	4	9	4	10	3	10	3	10	3	12	1	12	1*
1923.....	7	4	3	5	2	7	0	7	0	7	0	7	0	7	0	7	0	7	0	7	0
1924.....	8	2	6	5	3	6	2	6	2	6	2	6	2	6	2	6	2	6	2	6	2
1925.....	11	3	8	5	6	6	5	7	4	7	4	7	4	7	4	7	4	7	4	7	4
1926.....	18	5	13	6	12	10	8	12	6	13	5	13	5	13	5	13	5	13	5	13	5
No. of Cases Operated on.....	57	18	39	26	31	35	22	41	16	42	15	43	14	9	5	1	1	1	1	1	1

289

* One patient living with recurrence; one patient dead of intercurrent disease without recurrence.

lymph-node involvement, only about 17 per cent. have survived at least this five-year period. This marked difference in longevity in the group without lymph-node involvement bespeaks again the importance of early diagnosis and therapy before the carcinoma has invaded the lymphatic tributaries.

Of the patients dead of carcinoma and in whom the cause of death has been ascertained, approximately 90 per cent. have died of distant metastases. Mediastinal and chest metastases were the most frequent site of involvement. The osseous system was next in order of frequency, to be followed by liver and abdominal metastases in about 15 per cent. of the cases. Skin and supraclavicular node recurrence was present in approximately 25 per cent. of those succumbing to their disease.

Only two patients of this group who have survived were under forty years of age. Three patients, one in the second decade and two in the third decade, the former without lymph-node involvement, have all succumbed. The virulence of breast cancer in the young has recently been stressed by Burton J. Lee,⁵ and in the few opportunities we have had to observe this group, our results have also been discouraging.

Of four patients who had preliminary biopsy, followed by radical operation at an interval of a few days, three are alive and well. The recurrence in this small group was a young woman, nineteen years of age, in whom the age factor is so striking as to account for prompt recrudescence. The two patients who returned subsequently with carcinoma in the remaining breast died of their disease.

We have not given pre-operative X-ray therapy to any patient in this group. Practically all have received some form of post-operative treatment.

It is extremely difficult to estimate the factor of X-ray or radium therapy or their combination as it affects the results of operative treatment. In the primarily reported series of cases, encompassing the years 1915 to 1924 and in which a five-year period of follow-up was possible, 17 per cent. of the patients were alive and well. In this series our results are slightly improved. Whether this difference can be attributed to X-ray therapy is conjectural.

No attempt has been made to analyze the size of the tumor or its duration as it affects prognosis because of the small number of cases in this series. Suffice it to say that no patient with ulceration of the skin, peau d'orange, or redness and infiltration of the surrounding skin has lived for a five-year period.

Summary.—A series of breast carcinomata admitted between the years 1922 and inclusive of 1926 are reviewed with particular reference to end-results.

(1) At this writing, a follow-up period of at least five years, 23 per cent. of the patients are alive and well.

(2) At the end of five years' follow-up, fifteen patients of this series are alive and well.

(3) Three patients in this series died of carcinoma after a five-year period of longevity.

CARCINOMA OF BREAST

(4) Forty per cent. of the patients without lymph-node involvement have survived a five-year period; whereas only 17 per cent. with lymph-node involvement have lived for this period of time.

CONCLUSIONS.—The results of the treatment of breast cancer as seen on a general surgical service are still far from encouraging based upon a sufficiently long period of follow-up.

The relatively benign course of those patients without lymph-node involvement would indicate that our results will improve with refinement in diagnosis, the extent of the disease, and the age of the patient.

BIBLIOGRAPHY

¹ Cartnett, J. B., and Howell, J. C.: *Amer. Surg.*, vol. xci, p. 811, June, 1930.

² Lenz, Maurice, and Freid, Jack R.: *Amer. Surg.*, vol. xciii, p. 278, January, 1931.

³ Jennings, John E.: *Surg. Clin. of North America*, vol. vii, p. 895, August, 1927.

⁴ Moschcowitz, A. V., Colp, R., and Klingenstein, P.: *ANNALS OF SURGERY*, vol. lxxxiv, p. 174, August, 1926.

⁵ Lee, Burton J.: *Arch. Surg.*, vol. xxiii, p. 85, 1931.

PERIMESENTERIC INTRA-ABDOMINAL HERNIA

By ARTHUR MORTON SMITH, M.D.

OF CLEVELAND, OHIO

FROM THE DEPARTMENT OF SURGERY OF THE CLEVELAND CITY HOSPITAL, AND THE SCHOOL OF MEDICINE OF WESTERN RESERVE UNIVERSITY

HERNIAS through abnormal openings of the mesentery of the small intestine are rare. Hertzler¹ refers to only one case of this type which was reported by Little in 1871. Watson² states that in sixteen hundred autopsies an opening in the mesentery was found in three, all of which were located near the ileocaecal junction and in none of which was a hernia present.



FIG. 1.—Opening in the mesentery through which the sigmoid passed. The darker portion of ileum was carried through the opening with the sigmoid, and was gangrenous.

Moynihan³ in his monograph on internal hernia merely mentions this type.

Brown⁴ in 1920 collected nineteen cases from the literature and reported one, and Cutler⁵ in 1925 added to these six from the literature and reported two more of his own. Since then there have been seven cases reported to which I wish to add another. The case reported by Little in 1871 is also included in this report.

CASE I.—The patient, a white girl, twelve years of age, walked into the hospital November 17, 1930, at 5.30 P.M., complaining of pain in the abdomen and vomiting. Two days previously she had experienced sudden severe pain in the epigastrium followed by

vomiting. Following several doses of castor-oil and enemas, her parents stated that the bowels moved with the enemas, although both they and the patient were positive there was no blood passed and there were no tarry stools. The cathartic caused severe abdominal pain. The only essential point in the past history was occasional pain in abdomen for two weeks previous to the onset of the present illness. There was no history of trauma. The patient's bowels moved regularly prior to her present illness.

The patient was a well-developed but poorly nourished white girl of twelve years, acutely ill. Her temperature was 38.2°C . The abdomen was moderately distended but no peristalsis was seen. There was rigidity and tenderness over the entire abdomen, more marked in the lower portion in the mid-line. Shifting dullness could not be elicited. On auscultation no borborygmus was heard. Rectal examination revealed slight tenderness anteriorly but no palpable mass. The patient became rapidly worse, vomited several times, and expired forty minutes after admission.

Autopsy was performed the same day. The peritoneal cavity contained three hundred cubic centimetres of bloody fluid. In the lower abdomen there were several loops of large bowel which were gangrenous. There was an opening (Fig. 1) in the mesentery of the small intestine measuring 8 by 7 centimetres situated about ten centimetres above the ileocæcal junction. The edges were smooth and blood-vessels could be seen in the mesentery at the edge of the opening. The sigmoid had a long mesentery, was twisted on itself once, and had passed through the mesenteric defect twice. It was wrapped around the ileum attached to this region of the mesentery and had carried this portion of the ileum through the opening with it as it passed through the second time. This loop of ileum was gangrenous and distended, as was the twisted portion of the sigmoid. The hernia could not be reduced without enlarging the opening in the mesentery.

The ileum above the strangulation contained dark blood. No gross blood was found below the volvulus. The stomach and small intestine above the strangulation were dilated.

Practically all of the literature on this subject, as Cutler has pointed out, is in the form of case reports. Most text-books either do not mention it or refer to it very briefly. The origin of these mesenteric defects has been the source of considerable speculation. It seems to me that most of these anomalies are congenital and can be easily explained on a purely mechanical basis if one recalls the embryological development of these parts.

One should bear in mind that the weakest point in the mesentery is an area near the ileocæcal junction where there is an area free of fat, lymph-nodes, and blood-vessels, and that it is in this region the openings are nearly always found. During the seventh week of fetal life, as Mall⁷ has said, the rapidly enlarging liver occupies so much space in the small abdominal cavity that there is insufficient room for the expansion of the intestinal tube. The greater part of the intestine, in consequence, is displaced from the abdominal cavity into the cœlom within the umbilical cord, and when the intestines are pushed out a hole is sometimes made in the mesentery at its weakest point. This is a very plausible explanation of the formation of these defects.

There probably are some, however, which are the result of trauma in later life, *e.g.*, those in which the openings are slit-like and whose edges are ragged. The case reported by Brown⁴ is the best example of this and the symptoms in that instance began after a fall. The opening was slit-like with ragged edges and was apparently of recent origin.

Another theory on the congenital origin of these defects is proposed by

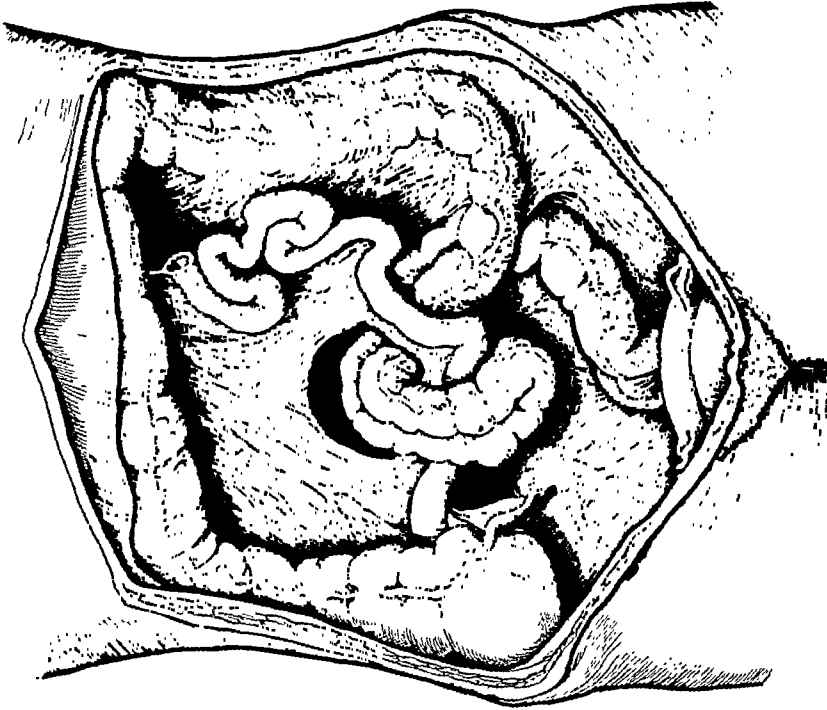


FIG. 2.

FIG. 2.—Diagram showing defect in mesentery situated near the ileocecal junction. The sigmoid, which is twisted 180° , is shown as it entered the defect the first time.

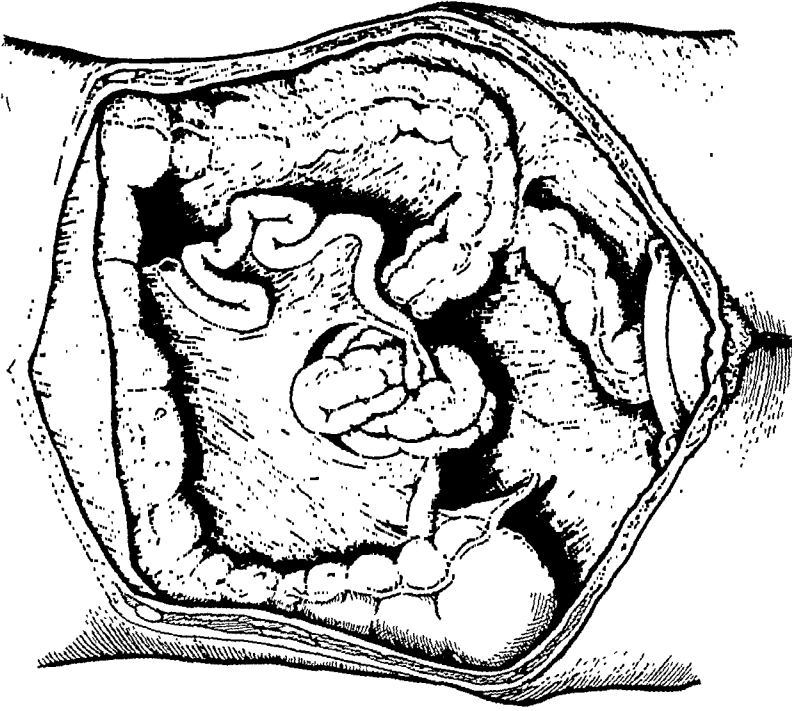


FIG. 3.

FIG. 3.—Diagram showing the sigmoid passing through the defect the second time carrying with it the adjacent ileum.

Federschmidt. He says that there is a physiological regression of the mesentery which only involves the ventral mesentery in humans but in other mammals it also occurs in the dorsal mesentery. Therefore, he says it is an atavistic characteristic. The objection to this was that it did not explain why the opening only occurred at the lower end of the mesentery. The case reported by Long,⁹ however, lends support to this theory as there were several fenestræ scattered along the entire length of the mesentery.

Hommes⁸ is of the opinion that there are definite anatomical relationships which cause these defects. He says Treves found that the ileocolic artery

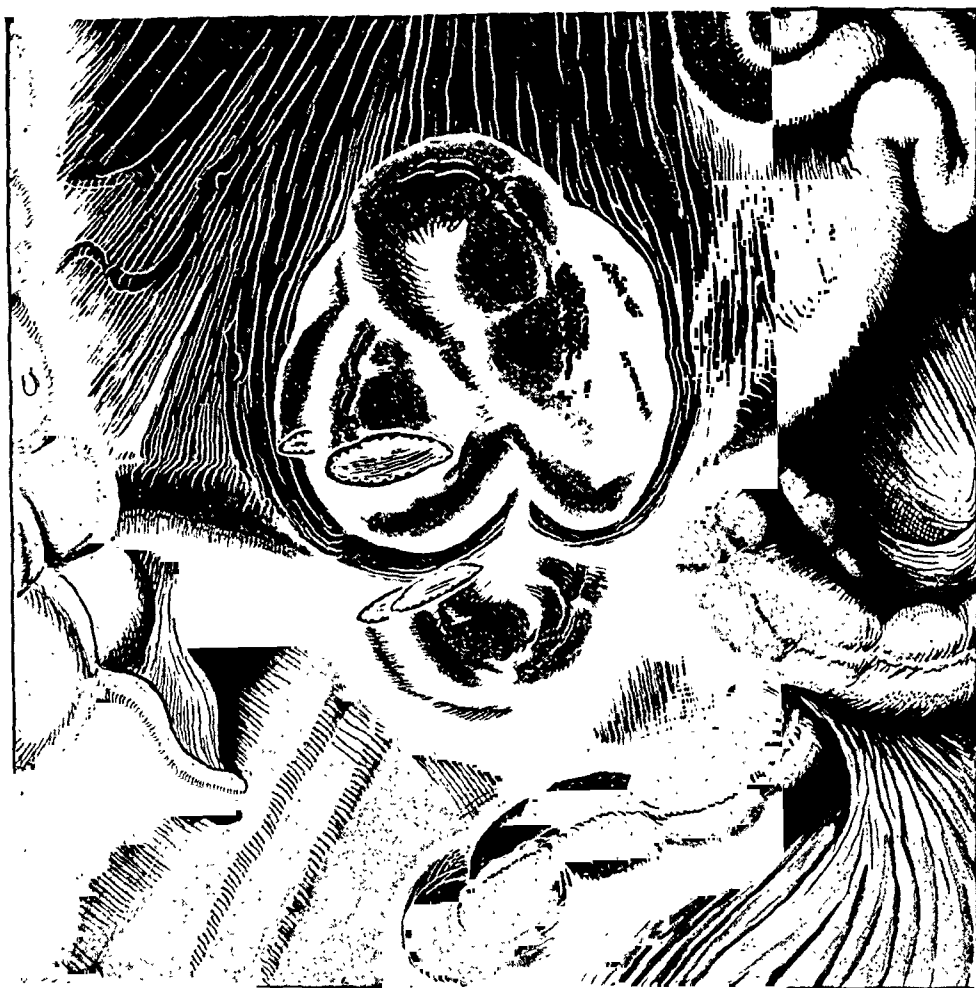


FIG. 4.—Diagram showing rotation and consequent strangulation of ileum. The shaded bowel represents that portion which was gangrenous.

and its anastomosis with the last large artery of the small intestine incloses a field which contains neither fat, lymph-nodes, or blood-vessels, and it was here that the defects were found by him. In the two cases reported by Hommes the opening lay between the strongly developed right colic artery and the artery ileimagna so that a true ileocolic artery was missing.

The superior mesenteric artery supplies the lower ileum, cæcum, appendix, and ascending colon. It develops out of the originally paired and later single omphalomesenteric artery, and travels many segments caudally so that variations are frequent. Hommes convinced himself through many laparotomies that the blood supply of the lower ileum comes for the greatest part from a

large branch of the superior mesenteric artery (artery ileimagna) which has a small anastomosis with the ramus iliacus which is the smallest developed branch of the ileocolic artery. In both of his cases the ileocolic artery was missing and the artery ileimagna was well developed and ran along the medial border of the defect.

Hohlbaum⁶ and Prutz believe inflammation is the cause of these defects. As a rule no signs of inflammation can be made out and since mesenteric defects do not occur after peritonitis, it seems highly improbable that inflammation plays a part in their formation.

SUMMARY OF CASES REPORTED OF MESENTERIC DEFECTS AS A CAUSE OF INTESTINAL OBSTRUCTION

CASE I.—Reported by C. G. Franklin. Male, seventy-three years old. History.—Intestinal obstruction five days. Sudden abdominal pain. Vomiting became fecal two days before admission. Operation.—Opening enlarged. Reduction. Findings.—Coil of small intestine 6 inches long tightly strangulated in aperture of mesentery. Pathology.—Bowel deep red, port-wine color and deeply indented by ring. Result.—Recovery.

CASE II.—Reported by J. G. Smith. Male, twelve years old. History.—Three weeks before pain and vomiting. Improved. Three days later had another attack. Operation.—Reduction. Findings.—Bloody fluid in abdomen. Loop of strangulated intestine, very dark color, through hole in mesentery. Pathology.—Very dark-colored strangulated loop bowel through hole in mesentery. Result.—Recovery.

CASE III.—Reported by J. S. Smith. Female, fifteen years old. History.—Sudden abdominal pain and vomiting. Symptoms of intestinal obstruction followed, lasting until operation on fourth day. Operation.—Reduction. Findings.—Greatly congested loop of intestine in hole in mesentery $2\frac{1}{4}$ by 2 inches. Pathology.—Congested loop of intestine through hole which had smooth thick margin. Congenital in type. Result.—Recovery. Remarks.—No history of trauma.

CASE IV.—Reported by J. Clark. Female, fifteen years old. History.—Sudden abdominal pain and vomiting. Fourteen hours later in state of collapse. Complete intestinal obstruction. No operation. Pathology.—Autopsy—Thirty ounces bloody fluid in abdominal cavity. Four feet lower ileum strangulated through aperture in mesentery. Evidence of old peritonitis in this area. Result.—Death three hours post-operative. Remarks.—Four years previously had been run over by a trap.

CASE V.—Reported by A. P. C. Ashhurst. Male, twelve years old. History.—Patient fell and hurt hip; next day dietetic error. Abdominal pain, vomiting and symptoms of intestinal obstruction for three days. Abdomen distended; fecal vomiting; blood and mucus by bowel. Operation.—Resection 14 to 18 inches intestine. End-to-end anastomosis. Drainage of pelvis. Findings.—Fecal-smelling bloody fluid in abdomen. Black coil of gut in pelvis resembling volvulus. Pathology.—Hole in mesentery. Ileum passed through until stopped by base of Meckel's diverticulum. Result.—Death three hours post-operative. Remarks.—Umbilicus suggested Meckel's diverticulum. Fell and hurt hip day before abdominal attack.

CASE VI.—Reported by J. B. Deaver. Male, twelve years old. History.—Sudden severe pain while cranking car; relieved. Six months later while again cranking car severe pain; did not subside. Moribund on admission. No operation. Pathology.—Autopsy—Strangulated, gangrenous coil of intestine through a congenital hole in mesentery. Result.—Death. Remarks.—Pain while cranking car twice, six months' interval.

CASE VII.—Reported by W. A. Lane. Male, ten years old. History.—Sudden, violent pain came on while asleep, in central part of abdomen. Vomited. Thoroughly purged by family physician. Two days later collapsed and became moribund. Operation.—Second day after onset. Findings.—Mass of bluish intestine $3\frac{1}{2}$ feet long passed

INTRA-ABDOMINAL HERNIA

through $\frac{7}{8}$ -inch hole in mesentery. Lower end was 2 feet above ileocæcal juncture. Pathology.—Foul-smelling bloody fluid; gangrenous loop $3\frac{1}{2}$ feet long through hole in mesentery $\frac{7}{8}$ inch; rough edges. Result.—Death on operating table. Remarks.—Attack came on while asleep. No history of previous attack or trauma.

CASE VIII.—Reported by L. J. Mitchell. Male, eight years old. History.—Second day after fall downstairs had severe abdominal pain. Diagnosed by outside physician as peritonitis. No operation. Pathology.—Autopsy—Opening in mesentery near ileocæcal juncture. Several loops of strangulated bowel through smooth-margined hole in mesentery. Result.—Death fourth day. Remarks.—Fell downstairs, landing on abdomen; apparently unhurt. Two days later abdominal symptoms.

CASE IX.—Reported by A. B. Atherton. Male, fourteen years old. History.—Pain began with dietetic indiscretion. Patient was well purged with calomel. Seen second day after onset of symptoms of obstruction. Operation.—Removed a twisted Meckel's diverticulum; relieving obstruction. Findings.—Loop of ileum one foot long through hole in mesentery 6 inches from ileocæcal juncture, not gangrenous and easily reduced. Post-mortem examination. Result.—Death third day. Remarks.—Subject to attacks of abdominal cramps since six years old.

CASE X.—Reported by Mauclaire. Female, twenty-one years old. History.—Signs of complete intestinal obstruction for five days. Mass palpated between umbilicus and pubis. Operative findings.—Strangulation of 30 to 40 centimetres of intestine through hole size of palm of hand in mesentery. Pathology.—Margin of hole denoted it had been of long standing. Result.—Death ten hours post-operative. Remarks.—She fell some days before appearance of symptoms.

CASE XI.—Reported by E. C. Stabb. Female, thirty-eight years old. History.—Eleven days before admission had severe abdominal pain which lasted five days, then ceased. Complete obstruction since first attack of pain. In state of collapse. Operation.—Reduction. Findings.—Large intestine collapsed from cæcum to sigmoid. On exposing small bowel, a portion slipped out of a circular hole in mesentery $\frac{5}{8}$ inch in diameter, 3 inches from ileocæcal juncture. Blood supply good. Pathology.—Autopsy—Nothing further found. Result.—Death eight hours post-operative. Remarks.—Always suffered with constipation. No history of abdominal injury.

CASE XII.—Reported by F. W. Speidel. Male, adult. History.—Patient had severe abdominal cramps which became more severe on way home. No wound of abdomen. Pain one inch below and to the right of umbilicus. Vomiting bile. Given morphia freely; in 3 hours relieved.— $10\frac{1}{2}$ gr. s c. In short time given dose of opium and in fifteen minutes he was quiet. Urine oz. 2 obtained by catheter. No vomiting. Calomel oil Y enemas brought no results. Eleven days after onset operation. Operation.—Eleventh day. Reduction. Result.—Death seventh day post-operative. Eighteenth day after onset. No bowel movement. Remarks.—Man shot by companion while hunting. Part of charge entering thigh and arm. While on way to sudden attack of cramps, had a bowel movement. At instant shot was fired threw up his hand and pitched forward on the ground.

CASE XIII.—Reported by N. Macphatter. Female, seventy-three years old. History.—Patient complained of not feeling well and inability to move bowels. On the fourth day showed symptoms of intestinal obstruction. Operation.—Hole enlarged. Reduction. Hole closed. Findings.—Loop of bowel through mesentery, twisted, not gangrenous. Result.—Recovery. Remarks.—No history of trauma.

CASE XIV.—Reported by G. K. Dickenson. Male, forty-five years old. History.—Symptoms of acute intestinal obstruction. Operative findings.—General peritonitis. Hole in mesentery in region of cæcum. Smooth margins 2 inches in diameter. A 2-inch coil of intestine through the hole. Result.—Not stated. Remarks.—Author does not mention duration of condition, condition of bowel, what was done, whether there was history of trauma or result.

ARTHUR MORTON SMITH

CASE XV.—Reported by W. D. Hamaker. Female, seventy-two years old. History.—Obstinate constipation for many years. Sudden onset of symptoms of intestinal obstruction. Operation third day after onset of acute symptoms. Operation.—Removed Meckel's diverticulum and gangrenous omentum. Reduced hernia. Findings.—Meckel's diverticulum rolled up in one edge of gangrenous omentum. Rent in upper part of mesentery, through which passed all transverse colon and omentum. Opening size egg. Condition evidently of long standing.

CASE XVI.—Reported by C. H. Frazier. Male, thirty years old. History.—Symptoms of acute intestinal obstruction. Operation third day after onset. Operation.—Reduction. Findings.—Eighteen inches of congested small intestine protruding through a slit in the mesentery, easily reduced. Pathology.—Slit probably of long standing. Result.—Recovery. Remarks.—Attack similar to present illness thirteen years ago. No history of trauma or dietetic indiscretion.

CASE XVII.—Reported by J. B. Roberts. Male, nineteen years old. History.—Pain and other symptoms of intestinal obstruction. No stool for five days. Abdomen distention. Operation.—Reduction. Findings.—In ileocæcal region, small intestine entangled in an opening in mesentery. Easily reduced. No gangrene. Orifices seemed congenital. Pathology.—There was apparently no actual protrusion of a loop through mesenteric opening but the bent intestine was thrust into opening so that sharp bend closed lumen. Result.—Recovery. Remarks.—Somewhat similar attack one year previously.

CASE XVIII.—Reported by Giovanoff. Result.—Recovery. Remarks.—Incarcerated intestine in aperture of vitello-intestinal duct.

CASE XIX.—Reported by Herczel. Result.—Recovery. Remarks.—Intestine incarcerated with doubled volvulus in mesentery opening.

CASE XX.—Reported by H. P. Brown, Jr.⁴ Male, five years old. History.—Admitted two days after fall. Pain in abdomen and vomited; continued next day. No stool. Rigid, distended abdomen. No mass. Temperature 101°; pulse 140; respiration 46; white blood cells 21,000. Operation fourth day. Resection end-to-end anastomosis with Murphy button; whole closed in layers. Findings.—One-half litre blood-tinged fluid. Knuckle gangrenous; gut 20 to 30 centimetres presented a coil of lower ileum which had passed through a 3-centimetre opening in mesentery and twisted on itself two and one-half times. Opening 5 centimetres below cæcum had rough edges apparently of recent origin.

CASE XXI.—Reported by Pye-Smith. Male, thirteen years old. History.—Acute intestinal obstruction for four days. Operation.—Constriction relieved. Findings.—Constricting band was Meckel's diverticulum attached to mesentery, passing through hole in mesentery encircling bowel. Result.—Recovery. Remarks.—Bowels moved spontaneously twelve hours after constriction; relieved and piece of fish tin $3\frac{1}{4}$ by $\frac{3}{4}$ inch was passed.

CASE XXII.—Reported by W. E. Darnall. Female, forty years old. History.—One month after hysterectomy had pain, vomiting, and obstruction. Operation second day. Operation.—Twelve inches ileum. Resection and anastomosis with Murphy button; drain. Findings.—Through an opening in mesentery of second loop of ileum there had slipped a loop of first loop on left under spleen. Volvulus of loop gangrenous and perforation. Result.—Death five hours post-operative. Remarks.—Pelvis normal.

CASE XXIII.—Reported by Sohn. Remarks.—Adds another case to 52 on record with gap in mesentery of small intestine.

CASE XXIV.—Reported by G. D. Cutler.⁵ Female, nine years and three months old. History.—Severe abdominal pain and vomiting eighteen hours' duration. Temperature 100.8°; pulse 144; respiration 24; white blood cells 38,000, polynuclears 94 per cent., monocytes 6 per cent. Operation.—Resection of ileum and Meckel's diverticulum. Lateral anastomosis. Findings.—Loop of gangrenous ileum through hole in mesentery. Pathology.—Blood-stained free fluid; gangrenous loop of bowel 18 inches with Meckel's diver-

INTRA-ABDOMINAL HERNIA

ticulum. Result.—Recovery. Remarks.—No history of trauma. Previous attack six weeks before.—Appendicitis with peritonitis.

CASE XXV.—Male, six years old. History.—Pain in abdomen and vomiting twenty-four hours' duration. Temperature 103.5°; pulse 180; respiration 48. Tenderness and rigidity. Condition grave. Operation.—Resection. End-to-end anastomosis. Findings.—Bowel gangrenous; loop through small hole in mesentery. Impossible to manipulate it. Resection and anastomosis. Pathology.—Foul serous fluid; black loop bowel through hole in mesentery. Result.—Death on table. Remarks.—No history of trauma or previous attacks. Appendicitis with peritonitis?

CASES XXVI, XXVII, and XXVIII.—Reported by Hohlbaum. History.—In one case history tuberculous mesenteric adenitis. In two cases severe strangulation with alarming symptoms and rapidly spreading gangrene. Findings.—In one case anomaly of sigmoid present. In another case volvulus of loop.

CASE XXIX.—Reported by E. R. Long.⁹ Male, four days old. History.—No bowel movements, distention and vomiting. Operation.—Fourth day. Patient moribund, so nothing was done. Findings.—Bloody fluid in peritoneal cavity. Large loop of bowel without mesentery. Pathology.—Multiple fenestration of mesentery. Lower ileum passed through one of these openings and was twisted. Result.—Died. Remarks.—Only case with multiple holes. Herniation took place during intra-uterine life.

CASE XXX.—Report by Cabot.¹² Male, thirty years old. History.—Pain and vomiting. Operation.—Three feet of small intestine resected. Two-stage operation. Findings.—Three feet of greatly distended gut through opening near cæcum. Pathology.—Gangrenous bowel. Result.—Recovery.

CASE XXXI.—Reported by J. White.¹⁰ Male, eight and one-half years old. History.—Sharp stabbing pains in lower abdomen and "sickness." Abdominal pain four years previous. Operation.—Reduced hernia and volvulus. Findings.—Lower part of ileum, cæcum, appendix, and lower part of ascending colon slipped through 2-inch hole in mesentery and twice twisted on itself. Pathology.—Hole had smooth, thickened edges, and around it were some enlarged glands. Result.—Recovery.

CASE XXXII.—Reported by P. Muller.¹¹ Male, thirty-nine years old. History.—Sudden violent abdominal pain and vomiting. Constipation and vague abdominal pain for fifteen years. Similar attack twelve years previously. Operation.—None. Patient moribund when entered hospital. Bloody fluid in peritonitis. Sigmoid twisted 180 inches and herniated through hole in mesentery about 50 centimetres from cæcum. Small gut below hole gangrenous from pressure of thickened mesentery of volvulus. Adhesions between volvulus and mesentery.

CASE XXXIII.—Reported by Jos. R. Judd.⁷ History.—Severe abdominal pain and vomiting for three days. Operation.—Aspirated distended colon and reduced hernia. Closed defect. Findings.—Opening one inch diameter through which transverse colon passed. Result.—Recovery. Remarks.—Probably a congenital opening.

CASE XXXIV.—Reported by Little.¹ Findings.—Strangulation from slipping of gut through hole in mesentery.

CASE XXXV.—Reported by J. H. Hommes.⁸ Male, five years old. History.—Abdominal pain, vomiting, and constipation of five days' duration. Operation.—Resection and lateral anastomosis of small intestine. Findings.—Cloudy straw fluid. Bluish-red intestinal loops through opening in mesentery. Results.—Died three hours post-operative. Remarks.—True ileocolic artery missing.

CASE XXXVI.—Male, sixteen years old. History.—Sharp pain in right lower quarter of sixteen hours' duration. No flatus since onset. Operation.—Reduced hernia. Findings.—Intestine loops gone through hole in mesentery 15 centimetres long and fallen into pelvis. Pathology.—No other openings. Result.—Recovery.

CASE XXXVII.—Reported by Smith. Female, twelve years old. History.—Sudden severe abdominal pain with vomiting for two days. Constipation. Operation.—Not done. Patient died forty minutes after walking into hospital. Pathology.—Volvulus of sigmoid,

which had passed through hole in mesentery near cæcum, had gone through hole twice and carried with it the ileum attached to portion of the mesentery where the opening was located. Result.—Died.

The diagnosis usually made in this condition is intestinal obstruction. Several cases, including the one reported, were diagnosed acute appendicitis. In no case was the condition diagnosed before operation.

The mortality is high, over 50 per cent. Of known end-results of thirty-one cases, sixteen died and fifteen recovered.

The symptoms in the majority of cases began three or four days before operation.

As to the type of operation, there were fifteen reductions with thirteen recoveries, and of seven resections only two recovered. If resection is necessary, it is best to do a two-stage operation. All those in which resection was done died except where a two-stage operation was performed.

Bloody fluid was present in the peritoneal cavity in many instances and various degrees of obstruction from simple mechanical obstruction without interference with the blood supply to strangulation volvulus and gangrene occur. In one case there was gangrene of the sigmoid and a portion of small gut.

The size of the opening varied from five-eighths of an inch to five inches. Most of the apertures were circular, a few slit-like, and only two of them were apparently of recent origin (Brown⁴ and Long⁹).

In the case reported by Long⁹ the herniation apparently occurred during intra-uterine life. It was the only case in which more than one opening in the mesentery was found but it was not possible to determine whether these were due to congenital defects or intra-uterine tearing. Certainly trauma had added to the extent of the fenestration during or after birth because the normal development of the intestinal wall could not have taken place with such an extensive loss of mesentery and blood supply as was found at autopsy. The extreme distention of the strangulated bowel may have torn the delicate mesentery, thus enlarging the opening in this case.

The age varied from the newborn to seventy-three years. The majority (eighteen of which the age is stated) were in patients less than twenty years of age.

Twenty males and nine females were affected on a ratio of about two to one.

Previous attacks of abdominal pain were mentioned in nine cases and a history of trauma was given in only seven cases.

Conclusions.—(1) A case of hernia of the sigmoid and a loop of ileum through an opening in the mesentery of the small intestine with gangrene of the herniated bowel is reported. The sigmoid was twisted on itself one hundred and eighty degrees.

(2) This condition is uncommon, only thirty-seven cases having been reported.

(3) The symptoms are those of intestinal obstruction, although some

INTRA-ABDOMINAL HERNIA

cases have been diagnosed acute appendicitis as in the case reported. Early diagnosis and operation offer the only hope of recovery.

(4) If resection is necessary, it is safer to do a two-stage operation, resection, and drainage, and later anastomosis of the bowel.

(5) The mesenteric defect is in most cases probably congenital in origin, although trauma may be a cause in some.

BIBLIOGRAPHY

- ¹ Hertzler, Arthur E.: *The Peritoneum*, vol. i, p. 212.
- ² Watson, Leigh F.: *Hernia*, p. 435.
- ³ Moynihan, Sir Berkley: *Retroperitoneal Herniæ*.
- ⁴ Brown, H. P., Jr.: *Intraperitoneal Hernia of Ileum through Mesenteric Defect*. *ANNALS OF SURGERY*, vol. lxxii, p. 576, 1920.
- ⁵ Cutler, George D.: *Mesenteric Defects as a Cause of Intestinal Obstruction*. *Boston Medical and Surgical Journal*, vol. cxcii, p. 305, 1925.
- ⁶ Hohlbaum, J.: *Über die angebomen Mesenterial Lucken als ursache von Darmein Klemmung*. *Biertr. Z. Klin. Chir.*, pp. 119-468, 1920. *Abstract Int. Abst. of Surg.*, vol. xxxi, p. 372, 1920.
- ⁷ Judd, Jos. R.: *Mesenteric Defects, with Special Reference to their Etiology and Report of Race Case of Colonic Obstruction*. *Surg., Gynec., and Obstet.*, vol. xlviii, pp. 264-267, February, 1929.
- ⁸ Hommes, J. H.: *Darmverschluss durch Einklemmung in Mesenteriallucken*. *Zentralbl. f. Chir.*, vol. lvii, pp. 862-865, April 5, 1930.
- ⁹ Long, E. R.: *Acute Intestinal Obstruction in Newborn Infant from Hernia of lower Ileum through a Congenital Mesenteric Opening*. *Trans. Chicago Path. Soc.*, vol. xii, pp. 335-337, June 1, 1927.
- ¹⁰ White, J.: *Hernia of Intestine Through Mesenteric Hole*. *Brit. M. J.*, vol. ii, p. 490, September 15, 1928.
- ¹¹ Muller, P.: *Un cas de volvulus colo-sigmoide hernie a travers le mesentere over etrangement de la masse de l'intestine giele par bride mesenterique*. *Bull. et mém. Soc. de chir. de Paris*, vol. xx, pp. 154-158, February 27, 1928.
- ¹² Cabot, R. C.: *Abdominal Hernia with Strangulation; General Peritonitis; Acute Appendicitis; Fæcal Fistula (Cabot case 13492)*. *Boston M. and S. J.*, vol. cxcvii, pp. 1094-1098, December 8, 1927.

TRANSACTIONS

OF THE

NEW YORK SURGICAL SOCIETY

STATED MEETING HELD FEBRUARY 24, 1932

The President, DR. JOHN DOUGLAS, in the Chair

UNUSUAL COMPLICATION IN A CASE OF MAMMARY CANCER; WELL ELEVEN YEARS

DR. FRANK E. ADAIR presented a woman, white, single, who came to the Memorial Hospital August 24, 1920, at the age of fifty-three years. Two months previously she had noted a small lump in the lower inner quadrant of the right breast. It was painless at first but as it increased in size it grew somewhat painful. The tumor was bulky, measuring ten by ten by ten centimetres. It protruded against the overlying skin and there was impending ulceration. The right axillary nodes were enlarged but clinically not positively involved with disease. Two low-voltage X-ray cycles were delivered to the right breast, right axilla and right supraclavicular regions during August and September, 1920, totaling ten treatments. Under irradiation the tumor diminished to approximately four by four by four centimetres. The chest plate was negative for metastasis. February 19, 1921, a radical amputation was performed. Doctor Ewing reported the tumor to be a "cellular plexiform carcinoma with cords of large clear cells. Many appearances are possible X-ray effects. These include general hydropic degeneration of cells; isolated foci of necrosis; general fibrosis in many areas; mucinous degeneration of stroma; round-cell foci; large areas of necrosis and infiltration by polymorphonuclear leucocytes. The lymph-nodes are free of disease."

The wound was left open and a skin graft performed three weeks later. It healed over promptly. (Fig. 1). Probably on account of the skin graft, no post-operative X-ray cycle was given. Three months following the operation the patient got an infection of the middle finger of the right hand with lymphangitis extending upward over the arm and right back. She recovered from this infection. During the past eleven years the patient has been observed every three to six months. There has never been any recurrence of the carcinoma to date. The patient returned to the Breast Clinic February 1, 1932, presenting a tender swelling over the third and fourth ribs at the site of the previous operation. It clinically suggests a periostitis or osteomyelitis of these ribs. X-ray plate made of the chest reveals no evidence of recurrence or tuberculosis present. Tangential view of the chest shows definite erosion of the ribs, especially the second, third and fourth on the right side at the site of the former operation. A fluctuant area developed at this site. The patient was taken to the operating room and a small incision made for drainage. About ten cubic centimetres of thick pus were evacuated. Culture was taken. The culture showed *Staphylococcus albus* and *aureus*. The reporter said that this case was unique in his experience. The patient had no injury to cause this. The irradiation given eleven and a half years ago was very light in comparison with the treatments

EXTENSIVE SQUAMOUS CARCINOMA

by the high-voltage machines delivered today; so that trauma and irradiation could be ruled out as causative factors of the osteomyelitis. Even though a skin graft was performed eleven years ago it is difficult to conceive of any possible infection at that time breaking out at this late day.

In this case one could anticipate this result of an eleven-year cure because no nodes were involved at the time of the operation. In such cases a cure is obtained following radical mastectomy in 70 to 80 per cent. in most good surgical clinics. In a group taken as a whole in the report of a years ago* on 199 cases of operable mammary carcinoma, he found 40.6 per

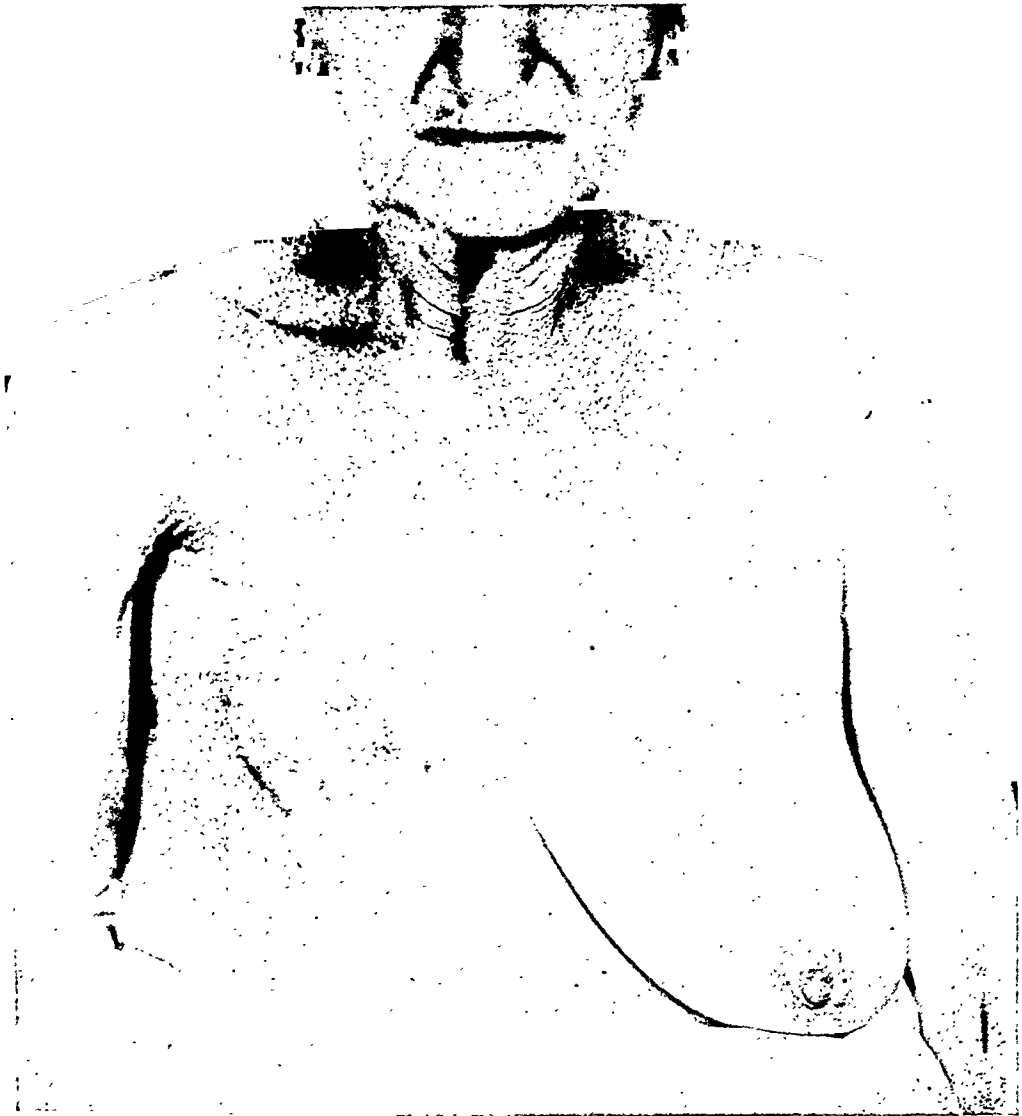


FIG. 1.—Showing the area of the skin-graft at which site eleven years later an osteomyelitis of the second, third and fourth ribs developed.

cent. living over five years treated by combined irradiation and surgery; while of those treated by irradiation alone (thirty-seven cases), 36.3 per cent. were alive over five years.

EXTENSIVE SQUAMOUS CARCINOMA TREATED BY INTERSCAPULO-THORACIC AMPUTATION; WELL EIGHT YEARS

DOCTOR ADAIR presented a man who came to the Memorial Hospital August 7, 1923. He presented in the right interscapular region, a flat, raised,

* Adair, Frank E.: The Results of Treatment of Mammary Carcinoma by Surgical and Irradiation Methods. ANNALS OF SURGERY, March, 1932.

indurated, ulcerated neoplasm the size of a twenty-five-cent piece. In the right axilla was a mass which was fixed to the chest-wall. From this mass a sinus was discharging. A biopsy from the axillary mass revealed squamous carcinoma. Chest plate was negative for lung metastasis. The patient was treated in the X-ray department by seventeen low-voltage X-ray treatments over the back and axilla for a period of eight months. During this time the axillary mass so bound the arm to the side that it was impossible to give effective X-irradiation. October 18, 1924, Doctor Adair made an inter-scapulo-thoracic amputation with an especially wide skin excision to include the epithelioma of the back as well as the bulky axillary mass adherent to the chest-wall. (Fig. 2.) By this procedure it was not possible to completely close the wound over the ribs in the region of the former axilla. A skin graft was done to cover the defect.

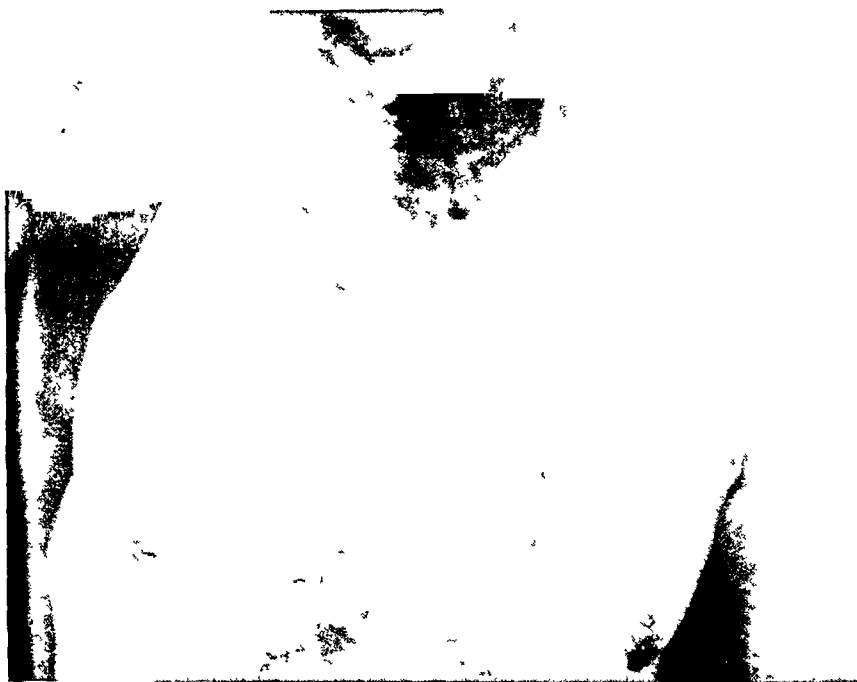


FIG. 2—Shows the amputation of the right arm and shoulder girdle; also the mass above the first rib. The latter has been inactivated by interstitial radon and external irradiation.

DOCTOR EWING'S pathological report was: "The specimen consists of an arm amputated to include the shoulder girdle. The axillary fold is the site of a carcinomatous ulcer ten centimetres long by five centimetres broad and in places five centimetres deep. It invades the pectoral muscle. Squamous carcinoma."

The patient had an uneventful post-operative recovery.

During the course of the next ten months several discreet nodes developed in the right supraclavicular region immediately above the first rib. During the next year this area was treated with four high-voltage X-ray treatments. October 16, 1925, under novocaine anaesthesia, the skin over the cervical mass was incised and ten gold tubes containing radium emanation were scattered through the mass, totaling 1,310 millicurie hours. The mass subsequently became densely fibrosed and has gradually diminished in size.

In April, 1930, the patient returned to the clinic presenting a mass measuring four by four by four centimetres in the left interscapular space. This mass was widely excised with its overlying skin, assuming they were dealing with a metastasis. It proved to be a sebaceous cyst. Today, the chest is still

negative for metastasis and there is no local or distant signs of any active disease eight years later.

DR. HENRY H. M. LYLE said that there was an unusual feature about this case. Examination of the spine shows lateral scoliosis to be absent. In the Depot of Ampute, just outside of Paris, in 1915, he had, through the kindness of Professor Tuffier, the privilege of examining several cases of interscapulo-thoracic amputations: they all had marked lateral scoliosis. The same has held for a few cases Doctor Lyle has seen since. In Doctor Adair's case could it be that the resultant fibrosis of this area and the X-ray treatment had counterbalanced the loss of the shoulder girdle and arm? The pull of the fibrous tissue was against the weight of the remaining arm.

INTRAPELVIC NEUROGENICAL SARCOMA IRREMOVABLE AT OPERATION. TREATED BY IRRADIATION. WELL TWO AND A HALF YEARS.

DOCTOR ADAIR presented J. O'S., a boy of thirteen years, who was referred to the Memorial Hospital Clinic October 14, 1929, from St. Vincent's Hospital, which he had entered because of incontinence of urine, painful micturition, no defecation for a week, sharp pain in the right upper thigh and the presence of a suprapubic mass. X-ray plates revealed the presence of a large mass filling the true pelvis and extending to the level of the fifth lumbar vertebra. The bladder was displaced entirely out of the true pelvis. The diagnosis of a retroperitoneal sarcoma was made, and an exploratory laparotomy was done August 24, 1929. The operation revealed a large mass extending from the true pelvis up into the abdomen, nearly to the level of the umbilicus. This mass appeared to be retroperitoneal but its point of origin could not be determined. It was soft; the tumor was aspirated and a section taken. It was then packed and the abdomen drained. The microscopical report on this material was "a very cellular neurogenic-sarcoma." The patient was then referred to the Memorial Hospital. On admission he was a very sick boy in bad general condition. The eight high-voltage X-ray treatments were begun October 8, 1929. He immediately commenced to improve. The mass began to diminish. By November 4, 1929 (one month later), he had gained nine and one-half pounds. The sinus was nearly healed and the suprapubic mass was rather indefinite to palpation. By December 23, 1929, no tumor was palpable. By March 2, 1931, a new mass had appeared in the left groin and the urine was offensive. Four X-ray treatments were instituted. Both the mass and the symptoms promptly disappeared. He is now entirely free of disease as far as one can make out symptomatically or on rectal examination. It is now two and a half years since his admission as a hopeless case.

This type of case must be observed frequently and therapy instituted at once if there is any sign of recurrence. The reason for the great success of irradiation therapy in this case is probably dependent on the youthfulness of the patient and the extreme cellularity of the tumor. The more cellular the tumor, usually, the more striking is the irradiation response. This illustrates the value of irradiation in a case of neurogenic sarcoma where it was impossible to treat by any known surgical measures.

SKIN GRAFTING IN CASES OF SEVERE BURNS

DR. FENWICK BEEKMAN presented four patients, three boys and one girl, to demonstrate the fact that it is possible to prevent contractures due

to scar tissue in severe burns and in cases in which the skin has been avulsed from large areas of the body, if immediate skin grafting is done. Two of these patients had been treated in this manner and were entirely free from contractures. In contrast, two other patients were presented, one of whom had a severe contracture of the knee and the other a contracture of the axilla and the cubital fossa. In both of these cases he believed that the contractures could have been prevented if they had had early skin grafting.

The most satisfactory type of skin graft is the full-thickness pinch graft, the grafts placed sufficiently close to each other to allow the surface between to heal within a week or ten days.

CASE I.—A boy, November 16, 1925, when ten years of age, was run over by a bus, the entire skin of the left leg being avulsed from the knee to the ankle, cleanly exposing the muscles, bones and vessels below the deep fascia. The wound was cleaned



FIG 3 —Third degree burn of complete circumference of leg from above ankle to inguinal region
Early pinch grafting No contracture. Case I

and the edges of skin débrided. He was treated by the Dakin method until the 18th of November, when the limb was placed in a hot-air tent, as a burn would be treated. There was surprisingly little infection. On December 18, the granulations being healthy, the popliteal space was grafted with about 175 pinch grafts. These having taken, a similar number were applied on the 12th of January, 1926, and others ten days later. The boy was discharged from the hospital, some three or four months later, with his leg practically healed. On March 24, 1928, three years later, he was re-admitted because of an ulcer of the skin, which would not heal, situated on the patella. The pre-patellar bursa which lay beneath the ulcer was excised and the wound skin grafted, following which it did not break down again. At present, he has healthy, elastic skin which seldom breaks down. He has a fair amount of motion at the knee-joint and can do almost anything the other boys do.

CASE II.—A boy, five years of age, on October 29, 1929, was burned by a bon-fire and was immediately brought to the Hospital for the Ruptured and Crippled. His left

SKIN GRAFTING IN CASES OF SEVERE BURNS

leg was burned from the ankle to the scrotum and buttocks. The left side of the abdomen and face were also involved. These latter burns were of second-degree intensity and left little, if any, scar. On the left leg, from just above the ankle to just below the trochanter, the skin for the entire circumference of the limb was destroyed through its full thickness.

The burns were treated with 5 per cent. tannic-acid solution. A satisfactory tan was obtained and on December 3, 1929, exactly five weeks following the accident, the tanned eschar having completely separated and the granulation tissue being extremely healthy, he was subjected to skin grafting. At this time, 150 full-thickness pinch grafts were removed from the opposite thigh and placed in the popliteal space, each graft being placed about one-eighth of an inch from its fellow. The grafts were covered with strips of paraffin gauze and a few layers of dry gauze. The remaining portion of the granulating surface was dressed with strips of vaseline gauze and covered with dry gauze. The entire leg was then surrounded by coarse non-absorbent cotton, which was firmly bandaged in place and covered with strips of adhesive plaster, crossing each other, to give additional pressure. The entire limb and hip were mobilized in a plaster casing. In a week's time the dressings were removed and the grafts were found to have taken.

December 13, 1929, ten days after the first grafting, a second was performed, the inside of the leg and thigh being covered with 150 additional grafts; and December 28, 1929, the third operation took place, the remaining external surface of the leg and thigh being covered with 150 grafts. All the grafts took, and, by the first of February, the entire lower surface of the leg was covered. The patient was discharged from the hospital April 5, 1930. Following this, an occasional ulceration developed which, however, was healed by ordering the child to bed. In July, 1931, he had an ulceration over the patella but, by means of rest, this was healed. His leg is now covered with a soft, pliable, elastic skin (Fig. 3) which does not break down, though the boy takes no particular care to prevent accidents. There is full range of motion at the knee-joint.

CASE III.—A boy, six years of age, June 5, 1930, had his clothes catch fire from a bon-fire and his entire left leg and thigh were burned. He was taken to a hospital where he was treated by means of sodium-bicarbonate dressings. Though the entire circumference of the leg lacked skin from just above the ankle to above the knee, no skin grafting was done. Consequently, the granulating surfaces slowly epithelialized from their edges and there developed a contracture. This patient was referred to the reporter May 12, 1931, almost a year following the accident. He was admitted to the Hospital for the Ruptured and Crippled. His left leg was then contracted at the knee to a right angle, a large, pale web of scar tissue having formed between the back of the thigh and the calf of the leg. The skin covering this area was thin and non-elastic and shiny. On the inner side of the leg there was an ulcer, measuring four by two inches, with a base composed of shiny, smooth, pale granulation tissue. The child, of course, was unable to walk. For a week, the leg was treated with wet dressings, by which the inflammation was reduced. May 20, 1931, eighteen days following admission, the floor of the ulcer was excised down to normal fascia. This area was covered with 150 pinch grafts. Ninety per cent. of these took and, in another week's time, the entire bare area was healed. August 19, 1931, the contracture was operated upon, the posterior surface of the thigh being incised transversely at the upper edge of the web. This incision was deepened and lengthened, as the knee was extended by an assistant, until normal tissue was reached. It was found that, by gradual pressure, the structures on the posterior surface of the popliteal space could be stretched and the leg straightened. The upper edge of the skin of the web was thereby drawn down to the mid-calf, leaving a diamond-shaped wound, measuring eight by four inches, which exposed the normal structures of the popliteal space. The tendons and nerves were exposed in many places, as the deep fascia had been destroyed. The upper border of this wound was composed of undamaged skin and the lower of scar tissue. A full-

thickness skin graft, measuring eight by four inches, was removed from the opposite thigh and sutured in this opening and the wound was dressed with gauze. The leg was wrapped in non-absorbent cotton, tightly bandaged and immobilized in a hip spica. The wound on the right thigh, from where the grafts had been obtained, was sutured, but this broke down in three or four days and the edges separated. September 1, twelve days following the operation, the plaster casing and dressings were removed. It was found that the entire Wolff graft had taken and that the leg was straight. A week later, the child was allowed to walk, as the deeper tissues of the leg were commencing to contract. The upper edge of the scar, which was healed to the lower border of the Wolff graft, ulcerated. September 16 this ulceration was excised and the raw area covered with pinch grafts, which healed. As the deeper tissues were contracting, the leg was placed in a plaster casing. The boy was discharged from the hospital October 14, 1931, wearing a brace to prevent the contracture of the knee. January 9, 1932, he was re-admitted to the hospital, as the old skin which covered the area upon the leg which had not been grafted had broken down and formed chronic ulcers. The knee, at this time, was found to be straight. This ulcerated area was excised down to normal fascia and pinch grafted. These grafts are seen to have healed. The patient now has full motion at the knee. There are no signs of contracture and the only complaint that he has is the breaking down of the poor epidermis covering the ungrafted area of the leg.

CASE IV.—A girl, aged eight years, was admitted to Bellevue Hospital June 2, 1931, with a third-degree burn which covered the upper part of the back of the trunk and both arms. The burn was treated by means of tannic acid but was not skin grafted. The areas of granulation tissue finally became covered with skin, the epithelium having extended in from the edges of the wound. She was discharged November 8, 1931, five months after admission, healed, but with some contraction of the left axilla and left elbow. She was re-admitted December 5, 1931. At this time the elbow could not be extended beyond a right angle and the arm could not be abducted more than forty-five degrees from the chest-wall. November 5, 1931, at the time of the meeting of the New York Surgical Society at Bellevue Hospital, the elbow was operated upon. A transverse incision was made across the upper edge of the web and carried down to normal tissue. At the same time the forearm was extended at the elbow. This left a triangular area, exposing the structures in the cubital fossa, about three inches long and two and a half inches wide. A full-thickness graft was removed from the opposite thigh and sutured into the space. The wound was dressed with gauze and non-absorbent cotton to produce pressure and the entire limb was encased in plaster. When dressed on the tenth day, the entire graft was found to have taken. January 4, 1932, a plastic operation was performed upon the axilla. The web formed an accentuation of the posterior axillary wall. Two flaps were formed by means of an incision in the form of an inverted Z, the oblique portion of the incision being made on the crest of the web. The upper flap, which was composed of more or less scar tissue, was transferred to the position of the lower flap. The lower flap, which contained healthy skin and subcutaneous fascia, was transferred to the position left vacant by the upper. The upper flap healed without difficulty, giving a healthy, soft skin for the axilla. The lower flap broke down and this area, on February 5, 1932, a month following the plastic operation, was covered with pinch grafts, which took. The child now can extend her elbow to about 170 degrees and can abduct her arm to about 120 degrees.

DR. CARL G. BURDICK said that he had experienced so much difficulty in handling these cases in the past in the effort to get them in condition for some form of grafting that he especially appreciated the results in Doctor Beekman's cases. With pinch grafts one is sure of getting enough skin to cover almost any area. Using tannic-acid treatment first one can get these

SKIN GRAFTING IN CASES OF SEVERE BURNS

patients in condition for grafting fairly early and with Dakin's solution they can be cleaned up in a short time and graft them before contracture has taken place. It is the ideal method of treatment and when the pinch grafts are placed close together one gets the same result as with full-thickness grafts over the entire limb.

DR. KIRBY DWIGHT said that the great advantage of pinch grafts is their resistance to the wear and tear of use; they are not so apt to suffer from abrasions and contusions as Thiersch grafts. Another point is the great importance of doing the grafting early. Waiting until it is evident that the skin cannot be covered with skin in any other way is a mistaken procedure.

DR. HENRY H. M. LYLE referred to a paper he read before this Society in 1926, entitled "Skin Plastics in the Treatment of Traumatic Lesions of the Hand and Forearm," the burden of the paper being that prompt healing is the essential requirement in obtaining functional use, and that much time and disability can be saved by the employment of suitable skin plastics. The advent of the Carrel method of treating war wounds and burns has taught that large granulating surfaces can be quickly sterilized and that they then can be covered by skin grafting with the assurance of a high percentage of takes. The closure can be obtained by primary or secondary skin grafts. Once having obtained an epithelial covering one is in a position to carry out any reparative procedure that may be indicated. When lesions involving a large destruction of skin are met with it is imperative that the surgeon should map out a plan that will lead to prompt healing and epithelization, having in mind the necessary procedures that will have to be employed to obtain a satisfactory functional result. To allow a large superficial wound to heal by granulation should be considered a surgical failure. Certainly it is a great economic waste.

DR. GRANT P. PENNOYER said that the most important factor in obtaining good grafts is the blood-supply to the graft. The explanation of the good results obtained from early skin grafts in burn cases is the establishment of the blood supply, which is not hindered by a heavy scar-tissue base. An important factor in skin grafting is a right amount of pressure on the fresh grafts. At Roosevelt Hospital rubber sponges are used to obtain this pressure.

DOCTOR BEEKMAN, in closing the discussion, said that one sees many bad results in burns due to lack of or improper grafting, resulting in severe contractures. It can almost be made a rule that the longer a wound remains open, the greater the resulting scar tissue. With early pinch grafting, one is enabled to heal a wound before sufficient fibrous tissue has formed to become scar tissue. Scar tissue constricts the blood-vessels; consequently, curetting the granulations down to the scar tissue is wrong; one should excise the new tissue down to a normal base. In cases in which Thiersch

grafting has been done, the skin is not elastic. With full-thickness pinch grafts, which act as elastic buffers, the area is soft and pliable.

TUBERCULOSIS OF THE GALL-BLADDER

DR. WILLIAM CRAWFORD WHITE presented a woman, fifty years of age, who was admitted to the Roosevelt Hospital March 5, 1931, with a three months' history of attacks of gall-stone colic. Physical examination was essentially negative. Intravenous dye failed to visualize the gall-bladder. No gall-stones could be demonstrated. Gastro-intestinal X-ray examination showed no pathology. At operation, March 12, 1931, the common bile-duct was found dilated and contained a spherical gall-stone about 3.5 centimetres in diameter. This was acting in a ball valve fashion. The gall-bladder was small, somewhat shrunken and had a growth on its fundus that suggested malignancy. Throughout the liver substance in the neighborhood were many punctate areas which suggested possible metastases. Through an upper right rectus incision the abdomen was explored. The common duct was opened and the gall-stone removed. The duct was then drained. After this the gall-bladder was removed and the cystic duct tied off.

The report from the pathological laboratory was:

Gross.—Gall-bladder measures seven centimetres in length and three centimetres in diameter at the fundus. The serosa of the fundus is thick and has a nodular furrowed appearance. It is resilient and firm on palpation and is covered by shining, opaque, yellowish-white serosa. The wall is thickened, averaging five millimetres. At the fundus the mucosa is ulcerated and has a granular rough surface with yellowish-brown excavations extending well into the wall. These are covered by hæmorrhagic exudate. The mucosa in the body of the gall-bladder and toward the duct outlet is smooth but the wall is markedly thickened.

Microscopical.—The gall-bladder mucosa is of normal type, single-layered epithelium. In the wall are masses of granulation tissue with monocytes and giant cells. Some typical tubercles are present. Attempts to demonstrate tubercle bacilli by staining were not successful.

Diagnosis.—Tuberculosis of the gall-bladder.

DOCTOR WHITE added that at operation he had been convinced that he was dealing with a carcinoma of the fundus of the gall-bladder, with minute metastases to the adjacent liver. The gall-bladder was removed largely because of his desire for a confirmation of his diagnosis. Consequently, no culture was thought of until it was too late, so that the complete proof is lacking. To date the patient has had an uneventful post-operative course.

PARATHYROID TETANY FOLLOWING SUBTOTAL THYROIDECTOMY

DOCTOR WHITE presented a man, thirty-one years of age, who was admitted to the Roosevelt Hospital August 7, 1928, with an eight months' history of exophthalmic goitre. Weight, 190 pounds. Basal metabolism, plus 44, although clinically he was much sicker than the test would indicate. A two-stage procedure was decided upon. One stage was performed on August 19, and the second stage on October 1, 1928. The parathyroid glands were not noted at the pathological laboratory. A report of toxic thyroid gland tissue was made. On the third day after the second operation the patient complained of cramps in both hands and both feet, duration a few minutes with relief obtained by massage. After discharge from the hospital, the symptoms persisted and he developed great weakness in his

PARATHYROID TETANY FOLLOWING SUBTOTAL THYROIDECTOMY

legs, so that he climbed stairs only with assistance. He was given 150 grains of calcium lactate a day, and after two weeks his blood calcium was 6.2 milligrams per 100 cubic centimetres. The dosage was raised to 200 grains of calcium lactate with a resulting blood calcium of 7.4. With the aid of an ampoule of parathyroid extract (Collip) per day, in addition, the blood calcium went up to 7.7 milligrams per 100 cubic centimetres (normal 9 to 11). The 200 grains of calcium lactate a day did not bother his appetite but gave him two or three loose stools per day. He had some improvement from this treatment. He complained especially of spasm in the hands when excited or when a sudden loud noise was heard. January 31 (about four months after operation), his blood calcium had dropped to 5.6 milligrams per 100 cubic centimetres. Dr. William Ladd, who took charge of him shortly afterward, gave him a high-calcium diet, calcium lactate, and parathyroid extract (Collip) every day for two months, then every other day for three months, and since then he has taken it every two weeks.

At present he weighs sixty pounds more than at the time of the operation, has a basal metabolism of minus 8 and blood calcium of 6.5 and feels fairly well. He no longer has spasms of his hands or feet, but complains of numbness at times in his legs which also feel, at times, like two sticks, and at these periods he loses all pep. He then takes an ampoule of parathyroid extract (Collip), and thirty-six grains of calcium lactate per day for a few days, after which he feels much better.

This man was presented as a case of mild post-operative thyroid tetany that failed to respond to calcium lactate alone, or parathyroid extract in association. His real improvement came about when the high-calcium diet was added.

DR. CHARLES GORDON HEYD remarked that as a complication of thyroidectomy tetany is neither infrequent nor rare. Not many parathyroids are actually injured during the course of a thyroid operation, nor with modern resection technic are they removed with the thyroid tissue, but what does happen, however, is that their blood-supply is frequently very seriously compromised by the manner and location at which the inferior thyroid artery is ligated.

It is readily possible to recognize two types of tetany as they occur after operations on the thyroid. It is not an infrequent experience to find a patient, twelve to fourteen hours after a subtotal thyroid resection, complaining of pain in both arms, midsternal pain, and peculiar tingling or formication of both upper extremities and occasionally a marked weakness in the lower extremities. Rarely, one does see at the end of twenty-four hours after operation a marked case of tetany with a typical accoucheur's hand. This group represents a transient or temporary form of tetany and is usually completely relieved before the patient is discharged from the hospital. Occasionally, some of these transient tetany cases require active treatment and the speaker's procedure has been as follows: A blood-calcium determination is the preliminary to all therapy. If the calcium is not less than 8.5 milligrams per 100 cubic centimetres of blood serum the symptoms are not apt to be either severe or prolonged. When the calcium reaches six, five or four milligrams, then there is progressively well-marked tetany. The procedure has been to administer calcium lactate by mouth, 100 grains

every two hours, for three doses, or to give ten cubic centimetres of a 10 per cent. sterile solution of calcium lactate intravenously. The acute manifestations of parathyroprival tetany can almost certainly be prevented by parathyroid hormone (Collip). As a rule the transient type of tetany is compensated for before the patient leaves the hospital but there is a group, represented by Doctor White's case, which may be designated as chronic tetany. Is this patient to take calcium lactate for the remainder of his life? Will he have to continue on a high-calcium diet of milk, peas, beans, eggs and sauerkraut? Will he have to continue intermittently or continuously with injections of parathyroid hormone (Collip)? There seems to be a well-founded belief that the taking of calcium lactate will maintain adequate calcium metabolism. It is very doubtful if over a long period of time patients with chronic tetany can avoid occasional treatments with parathyroid hormone. In view of the effect of ultra-violet therapy on rickets Jackson has treated one of his cases with ultra-violet light therapy and was able to report substantial changes in the dosage of calcium that was required after treatment in comparison with that which was used before. The question as to the transplantation of parathyroid glands is an interesting one. A few years ago surgeons were led to believe that parathyroid tissue grew abundantly on all the surfaces of the thyroid, and many of these supposed clumps of parathyroid tissue were transplanted. Most of them proved, however, to be only aggregations of fat cells and not parathyroid tissue. The effects of the transplantation of parathyroid tissue seem to be dependent upon the length of time that the graft survives in its new resting place, and the beneficial effects of the transplantation seem to be only temporary depending upon the time that is required for the transplant to be absorbed. It seemed to him that the progress made in Doctor White's case is very significant as a prognostic factor and that this patient should eventually work out of his tetany.

DR. WILLIAM BARCLAY PARSONS, JR., said that he had found that the use of powdered form of calcium gave better results than the tablets, particularly in one chronic case where a prompt improvement followed this change in the form of medication. He did not feel that it would be advisable for Doctor White's patient to attempt any definite reduction in weight through diet. The speaker has followed Lahey's process of inspection of the specimens and the removal of any suggestive pieces for reimplantation in the neck. Usually such pieces have been found to consist of fat; but on two occasions parathyroid tissue was found. These patients, however, showed no symptoms of parathyroid deficiency. Laboratory and clinical cases do not favor the attempt at transplantation of parathyroid from one individual to another, particularly as the majority of cases, after the use of parathyroid hormone and calcium by mouth, will subside spontaneously.

DR. EDWARD W. PETERSON referred to a case of congenital goitre which he presented before this Society about four years ago. The patient at that

time was a young woman twenty-three years of age. When five weeks of age she was admitted to the Post Graduate Hospital because of a large tumor in the right side of the neck which was diagnosed as lymphosarcoma, although there were no symptoms aside from the deformity. Under the impression that the diagnosis was correct, Doctor Peterson removed the tumor. It was made up of two masses, both of which had a slightly irregular, lobulated appearance, joined by an isthmus of fibrous tissue. Convalescence was normal, except for a brief rise in temperature to 105° , until the ninth day when symptoms of tetany appeared. At this time the pathologist reported the specimen to be a congenital thyroid tumor. Believing that the whole thyroid gland had been removed, thyroid extract was administered which was followed by a cessation of the tetany. The thyroid feeding was kept up for the first four years of the patient's life and since then, at regular intervals, thyroid extract and iodine have been given. Mental and physical development were perfectly normal up to the age of puberty, at which time a slight enlargement developed in the left side of the neck, corresponding to the left lobe of the thyroid. Microscopical sections from both specimens showed the same structure as that of the thyroid gland. The acini show a slight adenomatous proliferation but the epithelium does not show any malignant proliferation.

DR. J. WILLIAM HINTON said he had a patient who developed tetany in April, 1925, which was controlled with calcium chloride, intravenously, every day for a period of six days, then every two or three days for another eight days, after which time the patient left the hospital and was seen in his office at weekly intervals for two months when on each visit calcium chloride grains $15\frac{1}{2}$ was used intravenously. Then every two weeks for another two-month period.

At the onset of the symptoms immediately following operation Collip's parathormone would not control the symptoms. After September, 1925, the patient was symptom-free and remained perfectly well until January of this year, when she complained of over-weight. Basal metabolism done at that time was a minus 3, and the patient was advised to take thyroid extract grains $1\frac{1}{2}$, thyroid iodine dosage. Two days after thyroid medication was administered the patient had a return of her tetany. Thyroid extract was immediately discontinued and the patient's symptoms disappeared and she is now symptom-free.

This patient has had a low-calcium threshold, her calcium having gone to 6.5 while in the hospital, and it has remained under 8, although she had no symptoms seven and one-half years, until thyroid extract was administered.

FRACTURE OF EPIPHYSIS OF THE HEAD OF THE FEMUR

DOCTOR WHITE presented a boy who, in July, 1930, when fourteen years of age, hurt his left hip while playing baseball. He was unable to raise himself from the ground. X-rays showed a fracture dislocation of the epiphysis

of the head of the left femur, with displacement upward of the distal fragment. Under ether anæsthesia the fracture was reduced by the surgeon in attendance, and a Whitman hip spica was applied. He was kept in the casting for forty-two days. Measurement at this time showed a shortening of one inch of the affected limb. Another spica was applied with the thigh in 45 degrees abduction, 15 degrees flexion and internal rotation. This was kept on until November 10 (over four months). He then was instructed to use crutches for two months more without weight-bearing. One year later he had three-eighths of an inch shortening of the left lower extremity with slight atrophy of the thigh. The left thigh flexed only 80 degrees, and he walked without a limp. No limitation other than that of flexion. In the reporter's opinion, in this case the head of femur slipped some after the limb had been placed in an abduction spica. The original reduction had been excellent but not complete. If a similar situation arose again, he agreed with Cotton that an accurate reduction is indicated. If the closed method does not succeed, an open and accurate reduction is indicated in these adolescents.

DR. MATHER CLEVELAND (by invitation) said that Doctor White's case illustrates the excellent functional results that can be obtained without perfect anatomical results. These cases usually occur in patients from twelve to fourteen years of age as opposed to Perthes' disease, in which the age incidence is considerably younger. These two conditions, slipping of upper femoral epiphysis and Perthes' disease, seem to be allied. This case of slipping of the upper femoral epiphysis is of the traumatic type. There is another type which occurs from such an accident as stepping off a curb stone which may be disregarded for weeks and months until a limp is noticed. This may be bilateral with a very mild trauma. Doctor Cleveland showed some X-ray films of a patient with this second type who came to the hospital with a slipping of the femoral epiphysis. There was no severe trauma but six months previously she jumped off a step two feet high and the hip and leg hurt. She did not limp much at first but this symptom increased. Seen six months after this accident the slipped epiphysis was reduced and over-corrected. She was put in double plaster-of-Paris spica and then in a single spica. She was kept in plaster six months; during the last two months she was walking. Healing took place through absorption of the epiphyseal line. The union remained solid. Doctor Cleveland said he agreed with Doctor White that replacement should be obtained even if open reduction is necessary. This is to be accompanied by long immobilization.

DR. FENWICK BEEKMAN said he had seen two cases of slipped epiphysis of the neck of the femur in children. One was reduced and put up in a Whitman hip spica. In the other case, seen last autumn, the child had become gradually lame, following a slight jolt which she received in stepping off a pavement. A slipped epiphysis was shown by röntgenograms. It was decided to reduce this by means of traction. The child was put up with Russell traction on both legs, which were placed in full abduction. In a week's time, the epiphysis had almost returned into place. Finally, at the

DIVERTICULITIS OF SIGMOID; CARCINOMA OF SIGMOID

end of three weeks, there was complete reduction of the epiphysis upon the neck.

DR. SETH M. MILLIKEN referred to the case of a boy, thirteen years of age, who, while riding a bicycle, put his foot down for a sudden stop and felt a little pain. He went to the hospital three weeks later. The neck was found to have slipped off the head about one-fourth. He was put up in traction of about 30 degrees for one night, which reduced the displacement. The weight which held the head and neck in place was then diminished for four weeks, at the end of which time there was no further trouble. In six months he was walking without a limp. Traction is more comfortable than a spica.

DIVERTICULITIS OF SIGMOID; CARCINOMA OF SIGMOID

DR. HERMANN FISCHER presented a woman, sixty-five years old, first seen in the fall of 1930. At that time she complained of constipation, with alternating diarrhoea, and off and on blood and mucus in the stools. She had cramp-like pains in the abdomen, had lost some weight and strength. She brought an X-ray film along which showed a well-developed diverticulitis of the sigmoid. She was advised to enter the hospital for further examination, which advice she did not follow until June of the following year. She was then much sicker than before.

On admission she gave the following history: She was in excellent health until two years ago, weighed 175 pounds, did moderately heavy manual labor. At that time she began to lose her appetite gradually and then weight until she dropped to a weight of 126 pounds. She hardly eats at all. She has been constipated all her life, but more so during the past two years, and lately she has had to take cathartics continually to make her bowels move. She had occasional bleeding from the rectum, always red blood, usually between bowel movements, never profuse. This bleeding has been intermittent for the past two years.

Two days ago after a small bowel movement she began to have severe abdominal cramps over the entire abdomen, but much more severe in the left lower quadrant. She had had similar attacks, gradually getting worse, in the last two years.

She has been well all her life before this trouble started. She was a well-developed, fairly well-nourished woman, not acutely ill, who has evidently lost some weight. Rather pale. No jaundice, no gross deformity. Pulse, 96; temperature, 101°; respiration, 24; blood-pressure, 180/100. The abdomen was slightly distended and tympanitic throughout. No organs or masses or herniæ present. Quite distinct tenderness on deep pressure over the region of the sigmoid but no distinct tumor can be palpated.

Rectal Examination.—Mucous membrane smooth. No mass or ulceration as far as the examining finger can reach. There is, however, some pain when the finger presses against the anterior wall of the rectum.

Vaginal Examination.—Uterus small, anteverted. There is an irregular mass, painful on palpation in the posterior fornix. This mass is not movable and seems to be tightly adherent to the posterior wall of the uterus and filling the whole Douglas' pouch.

Blood Examination.—3,300,000 red corpuscles; hæmoglobin, 65 per cent.; leucocytes, 9,600; polymorphonuclears, 82 per cent.; large and small lymphocytes, 17 per cent.; eosinophiles, 1 per cent.

Urine.—1.014, cloudy. Albumin, plus. Sugar, negative. No casts.

X-ray Examination.—The barium clysma was rather unsuccessful as the patient was unable to retain the fluid until the upper colon was outlined. However, the colon, from the splenic flexure downwards, is well outlined with barium, and there is definite evidence of a diverticulitis in the sigmoid region. There is considerable distention of the coils of small intestine. This is probably due to some obstruction. The re-examination after forty-eight hours shows almost complete evacuation of the colon, with traces of barium in the diverticula.

Operation.—June 17, 1931, suprapubic mid-line incision from symphysis to umbilicus. On opening the peritoneal cavity there appears a moderate amount of clear peritoneal fluid. The great omentum is somewhat congested and its free border is firmly adherent to the cæcum, bladder, and sigmoid, covering the contents of the pelvis completely. The sigmoid flexure and the transverse colon and all of the loops of small intestine are greatly dilated due to an inflammatory adhesion between the mid-portion of the sigmoid, loops of intestine in the pelvis and the posterior surface of the uterus. The appendix is also caught in this mass.

The peritoneal adhesions are separated by sharp and blunt dissection, freeing the cæcum first. The appendix is removed. When the loops of small intestines are separated from the sigmoid an abscess containing about an ounce of foul creamy pus is evacuated. The sigmoid flexure can now be freed and a large and irregular tumor mass is found, practically taking in two-thirds of this part of the bowel. The mesentery of the sigmoid is then tied off and the loop of the intestine brought out of the abdominal cavity. It is then resected. The upper stump of the bowel is sutured to the upper angle of the wound and the lower stump to the lower angle of the wound. A cigarette drain is inserted into the pelvis below and above the lower loop of bowel and the incision sutured in layers around the opening of the gut. A Paul's tube is sutured into the upper opening of the gut for drainage and a dressing applied. The patient made an uneventful recovery and left with a well-working colostomy after a five weeks' stay in the hospital.

She re-entered the hospital again on the 27th of September, 1931, to have the colostomy wound closed and the bowel-lumen reconstructed. *Second operation.*—September 28, 1931, under spinal anæsthesia (neocaine 0.120) an elliptical incision is made around each of the two colostomy openings, separating the bowel from the skin. Each of the openings is closed by a tobacco-pouch inverting suture. After having thus insured an aseptic operative field, the colon is separated by blunt and sharp dissection from the adjacent tissues and adherent loops of intestine for the purpose of mobilization. The ends of the gut are freshened and an end-to-end anastomosis is done without any difficulty. The gut is dropped back and the abdomen is closed in the usual manner. She made a good recovery and is now in perfect health. Her bowels move regularly; she has no pain or mucus or blood in the stool and has gained about thirty pounds in weight.

Pathological report.—The specimen consists of an appendix and a portion of the sigmoid flexure of the colon. The portion of the sigmoid measures twelve centimetres in length and six centimetres in diameter. For one-half of its length it appears normal, except for a congestion of the mucosa. In the rest of it, the mucosa is replaced by a friable, papillated, reddish tissue of gray color. The muscular walls are here much thinned out and in two places small perforations have actually occurred through the whole thickness of the attenuated sigmoid wall. At this point and for a distance of five centimetres about it, there can be seen densely adherent dark gray and brown plaques of tissue on the serosal aspect of the specimen. On the other side of this

SPLENECTOMY FOR MOVABLE SPLEEN; TORSION OF PEDICLE

abnormal mucosa a thin strip of apparently normal mucosa can be discerned. Small diverticula can be found on probing through the more normal mucosa. On section a few phleboiths are found in wall as well as a lymph-node.

Microscopical Examination.—Section of the sigmoid tumor shows a typical adenocarcinoma composed of acini of various sizes lined with multiple layers of rather chromatic cells. The growth appears to be confined to the inner half of the wall. The superficial part exhibits a papillomatous structure and is extensively ulcerated. There is a marked inflammatory reaction of the stroma of the tumor and the involved gut wall. In the latter are noted numerous abscesses lined with granulation tissue which is rich in mononuclear wandering cells and giant cells. Sections of several of the diverticula show them to be lined with atrophic mucous membrane. Sections of the appendix show the usual picture a catarrhal appendicitis and acute peri-appendicitis.

SPLENECTOMY FOR MOVABLE SPLEEN; TORSION OF PEDICLE

DOCTOR FISCHER presented a young girl who had always been in good health. Ten days before being seen the girl was suddenly seized with a severe cramp-like pain in the lower left quadrant of her abdomen. This pain persisted steadily for about a week, then it disappeared and almost at the same time the patient noted a lump in her abdomen on the left side. While she had this attack of pain she also suffered from frequency of urination during the day and night.

Her abdomen presented no hernias, no tenderness. There was palpable a large firm mass which filled up about two-thirds of the entire left half of the abdomen. The tumor had a sharp lateral border and impressed one as having the general outline of an enlarged spleen. If the patient is in the erect position, the mass slips downward into the pelvis. It can be freely moved about almost clear across the abdomen to the right side. If that is done the patient complains of a nauseating pain, probably due to stretching of the pedicle.

In order to exclude the kidneys an X-ray picture after Skiadan injection was made. This examination demonstrated normal kidney pelves and ureters. No displacement. No apparent abnormality in the entire tract.

October 16, 1931, a five-inch left upper rectus incision was made. A large spleen, approximately twice the normal size, was readily brought up into the wound. It was firm in consistency, and there were no adhesions at any point. The pedicle was markedly elongated and the spleen had been twisted around the pedicle in two complete turns, so that the venous return seemed to be partially blocked. The surface of the spleen felt smooth, the capsule was thickened, but there was no infarction visible macroscopically. In many of the veins of the hilus thrombi could be felt. The pedicle was ligated and the organ removed. There was no bleeding or oozing and the abdomen was closed in the usual manner. The patient had no reaction after the operation and made an uneventful recovery.

The case was undoubtedly a congenital movable spleen which made no symptoms until pedicle torsion occurred. It was at the time of the twisting that the severe attack of pain occurred. In spite of the twisting and the concomitant interference with circulation no great damage to the organ occurred. It seems that there was no marked interference with the arterial blood supply, only the veins showed the thrombosis.

Movable spleen is a comparably rare occurrence in children and is then most probably of congenital origin, caused by a congenital laxity of the ligaments. Moynihan, as quoted by Pool, found a spleen in a boy of twelve which was so mobile that it lay in the left iliac fossa. The acquired type is more frequent and is found almost exclusively in adults associated with other

splenic pathology with enlargement of the organ. In these conditions the spleen becomes ectopic by its sheer weight.

LATE RESULTS OF OPERATIVE TREATMENT OF CARCINOMA OF THE BREAST

DR. PERCY KLINGENSTEIN read a paper with the above title for which see page 286.

DR. ALEXIS V. MOSCHCOWITZ said that there is general sympathy with such efforts, as that of Doctor Klingenstein, to improve technic by studying both the bad and good results. In this connection a very significant idea creeps in, namely, that all papers of this kind are based on statistics and more or less careful follow-up. One of the big errors is that the author is so honest that he leans backward. Doctor Klingenstein demonstrated this in the statement he made that the patients lost to follow-up are classified as having died in the first year. This may be valid to Doctor Klingenstein's statistics, but what the patient wants to know is: "What are my chances for recovery?" According to these statistics the answer would be, about 23 per cent. Only about 75 per cent., however, have been followed up and there is no way of actually knowing how many of the remaining 25 per cent. are still alive. Only a small number would greatly increase the percentage of recoveries. In his own practice, Doctor Moschcowitz said he has a large number of cases of six-, eight-, ten- and twelve-year cures. Only last week he met a patient living and well seventeen years after operation without recurrence. One day afterward she died of apoplexy. The New York Surgical Society would do well not to rely on statistics but rather on personal follow-up which will undoubtedly show a larger number of cures than 23 per cent.

DR. HOWARD LILIENTHAL said that he formerly treated his cases of mammary cancer by preliminary radiation but that he found that many of the patients were made nervous by the delayed operation, so that he, therefore, employs this treatment now in selected cases only.

He believed, however, that it was most important to have the lungs examined by X-ray before deciding upon radical operation, and that probably in the future we would find it wise to examine the spine and other bones for metastases. If the X-ray should disclose metastasis it would usually save the patient from an operation. He felt quite convinced that there were cases in which metastasis had been present and probably discoverable before operation.

DR. FRANK E. ADAIR felt that the author did not do his statistical results justice. He counts as dead any case that has lived more than five years but who has a recurrence present. This is not customary in statistical studies on cancer. This fact will probably account for part of the disappointing five-year results (23 per cent.) when compared with the author's previous communication on this subject published in the ANNALS OF SURGERY in

August, 1926, at which time he reported 34 per cent. five-year cures. It may be possible that Doctor Klingenstein is operating on cases that are more advanced than those previously. This may be justifiable in institutions where little dependence is placed on irradiation. In clinics where irradiation is intensively used the surgeon is apt to make a sharper line of operability because he is more inclined to lean on irradiation methods for that particular group of cases on the border-line of operability. Operating on the inoperable cases, except for palliation, does not redound to the good reputation of surgery.

Even today in many clinics the routine chest plate is not made before operation on a case of breast carcinoma. This should be insisted on. But the interpretation of that plate must be made by an expert röntgenologist. So many patients in the cancer age show shadows resultant from previous lesions, such as chronic bronchitis, old tuberculosis, *etc.*, that the röntgenologist of little experience, by a misinterpretation of the X-ray film, may easily deny a patient a chance of surgical cure. If clinical disease is located only in the breast, while no axillary or supraclavicular nodes are to be palpated, unless the röntgenologist is very certain of his interpretation, that patient should not be denied a radical mastectomy. Usually, with such a clinical setting, a consultation with the röntgenologist is necessary; if he is familiar with the vagaries of mammary cancer he will frequently recede from his diagnostic interpretation and admit his uncertainty of the presence of pulmonary metastasis in the presence of a clear axilla. The presence of but a small amount of pulmonary metastasis from a breast cancer is not an easy interpretation for the röntgenologist to make.

The surgeon should pay special attention and give prompt investigation to symptoms complained of by the patient, especially in the back, pelvis, or the knees. If the patient complains of "lumbago" or "rheumatism" in the hips or knees, a plate should invariably precede surgical intervention. In such a case it is common to have the plate reveal metastasis into the spine or pelvis. Patients especially complain of pain in the knees when the metastasis is located about the acetabulum.

It is Doctor Adair's rule to lay a row of gold seeds containing radium emanation, beginning at the very apex and extending to the base in all cases of involved axillæ. In not a few cases where a bad prognosis was anticipated, due to extensive axillary disease, he has been impressed with the effectiveness of this procedure and felt that the good results were due to the employment of interstitial irradiation.

DR. WILLY MEYER stated that at the time when the American Surgical Association reviewed the question of cancer of the breast it was positively shown that patients' lives had been greatly lengthened from the moment that radical cancer surgery of the breast was introduced. The statistics presented at that time were most convincing. The first patient whom Doctor Meyer operated upon in 1894, according to the principles as always advised by him,

lived for over thirty years and her case had been one of ulcerating cancer of the breast. In this case both pectoral muscles and the entire axillary contents were removed in one piece. Doctor Meyer endorsed the technical additions of George Semken, who also removes the sheath of the axillary vein and the entire fascia covering the serratus and intercostal muscles.

Doctor Meyer considered it a grave mistake not to remove the entire axillary contents, just because axillary nodes are not palpable on physical examination before operation. In every instance radical operation demands that the entire cancer field with the lymph-nodes should be removed and one should not trust to irradiation or the implantation of radium seeds to do the work the knife should do.

If any surgeon wants to satisfy himself that the above-described radical surgery is essential let him view those magnificent microscopical slides of Doctor Wainwright's, of Scranton, Pennsylvania. These slides prove the vital necessity of removing the entire pectoralis major and minor muscles with the cancer field if a real radical operation is to be performed. This type of operation is the hope and the future of the breast cancer patient.

DOCTOR KLINGENSTEIN, in closing the discussion, wanted to correct the impression of Doctor Adair that the results in the series just reported compared unfavorably with a series published in 1926. The difference between the 36 per cent. five-year cures reported in 1926 and the 23 per cent. now reported rests upon the fact that the 36 per cent. refers to cases followed only for a five-year period; whereas the 23 per cent. deals with patients followed for at least five years. It will be remembered that cases were reported this evening as suffering from recurrence or succumbing after a five-year period of apparent well being. He hoped that the question of classifying unfollowed cases as dead of cancer might be obviated in the future by our ability to follow each and every patient operated upon with any type of cancer, by reason of a more complete and extensive follow-up service.

EDITORIAL ADDRESS

The office of the Editor of the *Annals of Surgery* is located at 131 St. James Place, Brooklyn, New York. All contributions for publication, Books for Review, and Exchanges should be sent to this address.

Remittances for Subscriptions and Advertising and all business communications should be addressed to the

ANNALS OF SURGERY
227-231 South Sixth Street
Philadelphia, Penna.

ANNALS *of* SURGERY

Vol. XCVI

SEPTEMBER, 1932

No. 3

TRAUMATIC RUPTURE OF THE INTESTINES CAUSED BY AUTOMOBILE ACCIDENTS *

BY H. HAMILTON COOKE, M.D.
OF LOWVILLE, NEW YORK

ALTHOUGH numerous agents can cause traumatic rupture of the intestines, only a few cases have been described as the result of automobile accidents. My purpose in this study is to present the clinical and necropsy observations in twelve cases of traumatic rupture of the intestines caused by automobile accidents. The necropsy in these cases was made at the Department of Pathology, University of Minnesota, between December 1, 1919, and December 1, 1929.

The cases under consideration have been divided into two groups: (1) Those in which death occurred primarily from the effects of general trauma, and (2) those in which the general trauma was relatively slight and death was due to the rupture of the intestines.

The first group (Table I) was composed of ten males and two females. Three of the male and one of the female subjects were less than fifteen years of age. The lesions were in the duodenum in two cases, at the duodenal-jejunal flexure in one case, in the jejunum in six cases, in the ileum in two cases, and in the ascending colon in one case. Multiple rupture of the intestines was not observed.

Two cases of rupture of the ileum and one case of rupture of the jejunum were associated with rupture of the stomach. The intestinal loop was completely severed in three cases and almost severed in one case; in eight cases the rupture varied in diameter from five to fifteen millimeters. Free blood was present in the peritoneal cavity in eleven cases. The quantity varied from 250 to 2,000 cubic centimetres. In two cases, the rupture of the intestine was associated with injury to the liver, spleen and kidneys, in two cases with injuries to the liver and spleen and in one case with injury to the pancreas. The mesentery was cut across in one case, lacerated in two cases, and infiltrated with blood in two cases. The quantity of blood found free in the peritoneal cavity appeared to vary with the degree of injury to the liver, spleen, mesentery and pancreas. General fibrinopurulent peritonitis occurred in four cases in which the patients lived forty-eight, forty, and thirty-eight hours after injury.

* Work done at the Department of Pathology, University of Minnesota, while a Fellow in Surgery of The Mayo Clinic.

Quain, in 1921, reported the case of a girl aged fifteen years, who was thrown from an automobile. An operation was performed forty hours after the injury. Two small perforations in the jejunum, two centimetres from the duodeno-jejunal juncture, were closed with sutures of linen and catgut. After a stormy convalescence the patient recovered completely.

Vance, in 1923, reported two cases: One, in which a male, aged fifty-seven years, was run over by a motor truck. He was unconscious for about seven hours and died about nine hours after the accident. Necropsy disclosed a hole, four centimetres in diameter, in the middle of the omentum, a partial tear across the duodenum, and a complete tear of the jejunum, three feet from the duodenojejunal juncture. The second case was that of a man, aged twenty-nine years, who was struck by a motor truck. He was taken to a hospital and exploratory laparotomy was performed. A tear in the jejunum was sutured. The patient died of peritonitis several hours later. At necropsy, a complete transverse rupture of the jejunum was found forty-five centimetres from the duodenojejunal juncture. There was also a large contusion in the mesentery in the region of the intestinal injury. In 1928, Vance described two additional cases in which operation was performed. One of the patients recovered.

Bacon and Le Count have recently reported the necropsy observations in 303 cases of accidental death. Rupture in the intestine, due to automobile accidents, was found in nine cases. In one case, the rupture was in the transverse portion of the duodenum. The jejunum and mesentery were torn in three cases. The ileum was lacerated in four cases. One patient in this group lived for eighteen hours after the accident. A serious injury to the peritoneal viscera was suspected in one case, and exploration disclosed rupture of the colon. This was closed, but the patient died eight days later from general peritonitis.

In six cases, in addition to the intestinal injury, the severe general trauma caused death either immediately or very soon after the accident. Only three of these six patients reached the hospital alive. An injury to the intestine was not suspected, and the rupture was found only at necropsy. In the six other cases, the rupture of the intestine constituted the principal injury. The patients lived from nine to forty-eight hours, and died primarily from intraperitoneal hæmorrhage or peritonitis.

In general, the diagnosis of rupture of the intestine from automobile accidents depends largely upon the history and upon the observation of local and general signs and symptoms of an injury to the abdominal viscera. The history is of great importance. Care should be taken in noting the character of the accident. A passenger in an automobile which is stopped suddenly may sustain an injury of the intestine by being thrown against the seats inside the automobile. In one case, the patient was riding in the back seat of a light automobile when it collided with a street car. The patient was thrown forward and struck the anterior abdominal wall against the front seat. At necropsy, a large rupture was found on the anterior surface of the proximal portion of the duodenum.

The early signs and symptoms may be due to shock, rupture of the intestine, or intraperitoneal hæmorrhage. The degree of shock varies with the amount of general trauma. In the presence of slight general trauma, rupture of the intestine may produce few immediate symptoms. The patient may even be about for a short time without realizing the gravity of the condition. In ten of the twelve cases, the shock was slight in one case, moderate in one case, and severe in eight cases.

AUTOMOBILE RUPTURE OF INTESTINES

TABLE I
*Twelve Cases of Rupture of the Intestines Caused by Automobile Accidents.
Death Caused by General Trauma*

Case	Sex	Age	Abrasion on wall of abdomen	Duration of life; hours	Site of rupture	Size of rupture	Injury to stomach	Major associated lesions	Intraperitoneal hemorrhage -- cc --
7	M	45	None	1	Jejunum	Transverse		Subarachnoid hemorrhage tears in liver, kidneys left lung. Laceration of mesentery	300
8	F	12	Marked	1	Jejunum	Transverse	Rupture on greater curvature	Tears spleen, liver and hemo-thorax	250
9	M	23	Slight	1	Ileum	1.5 cm.	Rupture 4 cm. lesser curvature	Tears spleen, liver kidneys; fracture of skull.	1500
10	M	13	Moderate	1	Duodenum	Transverse		Tears spleen, liver pancreas.	1500
11	M	5	Slight	2 +	Jejunum	3.5 cm.		Fracture skull	400
12	M	65	None	3	Ileum	4.5 cm.	Rupture 5.5 cm. anterior wall near pylorus	Tears in spleen Hemo-thorax	300

In seven cases the skin over the abdomen did not show any abrasions, lacerations or wounds. (Table II.) Superficial bluish discoloration over the inguinal region was present in three cases; multiple superficial abrasions of the anterior abdominal wall were present in one case, and marked lacerations with deep wounds were present in one. Of the seven cases in which the walls of the abdomen did not show any evidence of injury, the intestinal rupture was transverse in two cases and partial in five.

By means of röntgenograms of the abdomen by the flat plate method, it is possible to determine immediately after the injury the presence of free blood, intestinal contents and excessive air in the peritoneal cavity. Such röntgenograms should be taken in every case in which symptoms are sug-

TABLE II
*Death Caused by Rupture of Intestines**

Case	Sex	Age	Duration of life in hours	Site of Rupture	Size of Rupture	Major Associated Lesions	Amount of Intraperitoneal Hemorrhage	Peritonitis
1	M	58	7	Jejunum	1.5 cm.	Fractured Pelvis	2,000 c.c.	
2	M	24	15	Ascending colon	7	Fractured Pelvis Laceration of Mesentery	400 c.c.	
3	M	7	38	Jejunum	.5 cm.	Fractured Pelvis	100 c.c.	Present
4	F	51	40	Duodenum	.8 cm.		300 c.c.	Present
5	M	39	40	Jejunum	Transverse	Fractured ribs Laceration of Mesentery		Present
6	M	55	48	Jejunum	7	Laceration of Mesentery	100 c. c.	Present

* Abrasions were not found on the abdominal wall in any case.

gestive of an intra-abdominal injury. The plate should, if possible, be made with the patient in a standing position. If the injury is associated with moderate or severe shock, board-like rigidity of the abdominal wall with rebound tenderness, increased tympany over the umbilical region, absence of dullness over the liver, and rectal tenderness, a presumptive diagnosis of intestinal rupture is justified and laparotomy should be performed as soon as possible.

The observations made in the twelve cases of rupture of the intestines caused by automobile accidents noted here are compared with the observations reported in the literature of rupture of the intestines in which the automobile was not designated as the etiological factor. (Table III.)

Since 1761 there have been reported in the available literature about 700 cases of traumatic rupture of the intestines. Primary rupture of the intestines may occur by crushing, tearing and bursting from increased pressure within the lumen. Secondary traumatic rupture of the intestines follows injury to the blood supply with localized gangrene and eventual perforation. Moty (1890) was the first to clearly classify the various types of traumatic

AUTOMOBILE RUPTURE OF INTESTINES

TABLE III
Rupture of the Intestines Not Caused by Automobile Accidents

Reporter	No. Cases	Cause of Accident					Location of Rupture					Extent of Rupture			*Without surgical therapy	With surgical therapy			
		Run over by vehicle	Crushed	Kicked by horse, cow or man	Blow	Fall	Miscellaneous	Duodenum	Jejunum	Ileum	Small intestine	Colon	Transverse	Partial		Multiple	No. operated on	No. recovered	No. died
Poland (1858)	61	9		11			41	4	14	16	22	5				61			
Curtis (1887)	116	13		28	29	13	4	6	44	38	21	4	20	96	11	104	12	0	12
Walters (1899)	21	5	3	6	1	4	2	1	6	7	2	5	2	17	2	6	15	3	12
Angerer (1900)	31															12	9	3	
Gage (1902)	85															45	40	17	23
Berry (1908)	132	51	24	16	23	11	7	26	32	32	25	10				48	84	17	67
Tschistov (1912)	52			16	9	11	16	1	23	25		3				5	47	8	39
Battle (1919)	215	74	25	28	35	27	26	32	111	59	2	11					124	48	76
Rowland (1923)	381							23	157	158		43			38				
Messie (1923)	34	16	7	2	6	1	2	4	14	8	3	1	9	20	5	3	31	7	24
Moynihan (1926)	17																17	3	14

*There were no recoveries in this group

intestinal rupture. Many forms of violence have been described as the cause of intestinal rupture. The older reports of Poland (1858), Curtis (1887), and Petry (1896) emphasized that the injury is most frequently due to a kick by a horse, cow, or man, and "run-over" accidents. The increase in the number of automobiles and frequency of automobile accidents, especially in the cities of this country, directs attention to the possibility that a large number of traumatic ruptures of the intestines occur in serious or fatal automobile accidents, although only a few cases are reported in the literature. In this report, intestinal rupture occurred in more than 5 per cent. of 210 fatal automobile accidents. The rupture appears to have been caused by crushing of the intestines in four cases and tearing of the intestines in eight cases.

In considering the individual cases in relation to the effect of the injury, they seem to divide themselves into two groups. In the first group, composed of six cases, subarachnoid hæmorrhage, crushing of the chest with hemothorax, laceration of the spleen, liver, kidneys and pancreas caused almost instantaneous death. The second group is composed of six patients who lived from seven to forty-eight hours after the accident. From the viewpoint of diagnosis and therapy, this is the most hopeful and therefore the most important clinical group.

Exploratory laparotomy was performed in only one case. A rupture in the ascending colon was found and sutured. Death from peritonitis occurred, however, fifteen hours later. In the other five cases a diagnosis of rupture of the spleen was made in one case, while in another the symptoms were so slight that medical attention was not sought until more than twenty-four hours after the accident.

Moynihan believes that exploratory laparotomy is justified in all cases where a rupture of the intestines is suspected, provided vomiting continues after a period of shock, and if the pulse-rate continues to increase. Lund emphasizes the early absence of serious symptoms. He recommends exploratory laparotomy in all cases of suspected traumatic intestinal rupture, without waiting for an absolutely definite diagnosis. If there is no hæmorrhage, or only a slight one from the mesentery and the margins of the rupture, the symptoms are produced by the escape of intestinal contents into the peritoneal cavity. Douglas considers early exploratory laparotomy indicated in all cases of severe abdominal injuries. "Then, in conclusion, in all cases of subperitoneal visceral injury, diagnosed or strongly suspected, if the general condition of the patient permits, laparotomy should be done; and success will be in direct proportion to the promptness of the intervention." Van Hooke and Kanavel consider exploratory operation necessary in every suspected case of intestinal rupture where proper facilities are available.

The pre-operative treatment is of great importance and should be directed to combat shock and hæmorrhage. The patient should be kept comfortable by warm blankets and hot-water bottles. Hypodermoclysis of .9 per cent. solution of physiological saline is of value. If the patient presents evidence of shock, blood transfusion should be done before the operation. After the

AUTOMOBILE RUPTURE OF INTESTINES

rupture is located and all bleeding points on the mesentery ligated, additional fluid can be administered by the intravenous route. Without early surgical therapy, death is inevitable. All of the 118 cases collected by Curtis proved fatal. In the series of Gage and Berry, all of the patients who were not operated upon died.

In four of the cases in this report in which the patients died from peritonitis, the lesion was found in the duodenum in one case, in the jejunum in three cases, and in the colon in one case. In the twenty-six cases of rupture of the intestines in automobile accidents reported by Quain, Vance, Bacon and Le Count, and myself, nineteen of the patients were not operated on. They died from shock, hæmorrhage or peritonitis. Operations were performed in seven cases, with two recoveries and five deaths. Reliable deductions are difficult to make from a small number of cases, but it appears clear that even with adequate early surgery the mortality rate is high.

Successful surgical therapy is influenced by many factors. The most important of these are: the degree of shock; the size of the lesion; the time elapsed after injury; the amount of hæmorrhage; the site of the lesion; the condition of the mesentery, and the presence of peritonitis. Rupture of the intestines should be considered as a possibility during the examination of all persons who have sustained an abdominal injury in automobile accidents. Since surgical therapy offers the only hope for recovery in rupture of the intestines, exploratory laparotomy is imperative.

SUMMARY

Twelve cases of traumatic rupture of the intestines were found in 210 victims of automobile accidents who came to necropsy at the Department of Pathology, University of Minnesota, between December 1, 1919, and December 1, 1929. The site of the rupture was as follows: Duodenum, three cases; jejunum, six cases; ileum, two cases; ascending colon, one case. In three cases the rupture of the intestines was associated with rupture in the stomach. In three cases the rupture was transverse and in one case nearly transverse, while in eight cases the size of the rupture varied from five to fifteen millimeters in diameter. The liver, spleen, kidneys or pancreas were injured in five cases. In seven cases there were no abrasions of the skin or any external evidences of injury to the abdomen. In four cases there were a few superficial abrasions, while severe lacerations of the wall of the abdomen were found in only one case.

Free blood in the peritoneal cavity was present in eleven cases. Peritonitis was present and the principal cause of death in four cases. In six cases (50 per cent.), death occurred within one hour after the injury was received. In this group the rupture of the intestines was associated with rupture of the spleen, liver, pancreas, kidneys, fracture of the skull, subdural hæmorrhage, multiple fracture of the ribs, and hemothorax. The result of therapy in this group is discouraging. In the other six cases, the rupture of the intestines was the most serious injury and with its complications was the cause of death. The symptoms and signs were identical with

those present in traumatic rupture of the intestines from other causes than automobile accidents. The duration of life was from seven to forty-eight hours after the accidents occurred. Death was the result of peritonitis in five cases, and from peritonitis and bronchopneumonia in one case. Exploratory laparotomy was performed on only one individual. Rupture of the intestines should be considered as a possibility, whenever a person has received a severe blow on the abdomen in an automobile accident. Lacerations and wound of the wall of the abdomen are infrequent, and their absence is not a reliable criterion for the condition of the intestines, viscera, or mesentery. Early exploratory laparotomy should be performed, when in doubt, since the expectant treatment is discouraging.

BIBLIOGRAPHY

- ¹ Angerer, V.: Ueber subcutane Darmrupturen und ihre operative Behandlung. Arch. f. klin. Chir., vol. lxi, pp. 970-987, 1900.
- ² Bacon, L. H., and Le Count, E. R.: Automobile Injuries. Arch. Surg., vol. xviii, pp. 763-802, 1929.
- ³ Battle, W. H.: Traumatic Ruptures of the Intestine. Lancet, vol. ii, p. 105, 1919.
- ⁴ Berry, J., and Guiseppi, P.: Traumatic Ruptures of the Intestine. Lancet, vol. ii, pp. 1143-1145, 1908.
- ⁵ Curtis, B. L.: Contusion of the Abdomen with Rupture of the Intestine. Am. Jour. Med. Sci., vol. xciv, p. 321, 1887.
- ⁶ Douglas, R.: Surgical Diseases of the Abdomen. P. Blakiston's Sons and Company, p. 635, Philadelphia, 1903.
- ⁷ Gage, H.: Abdominal Contusion with Rupture of the Intestines. ANNALS OF SURGERY, vol. xxxv, pp. 331-341, 1902.
- ⁸ Lund, F. B.: Rupture of the Intestine. Boston Med. and Surg. Jour., vol. cliii, pp. 603-608, 1905.
- ⁹ Makins, G. H.: On Two Cases of Traumatic Rupture of the Colon. ANNALS OF SURGERY, vol. xxx, pp. 137-170, 1899.
- ¹⁰ Massie, G.: Traumatic Intestinal Rupture. Lancet, vol. ii, pp. 640-644, 1923.
- ¹¹ Moty, M.: Etude Sur Les Contusion De L'Abdomen Par Coup De Pied De Cheval. Rev. de Chir., vol. x, pp. 878-915, 1890.
- ¹² Moynihan, B.: Abdominal Operations. W. B. Saunders Co., vol. ii, pp. 98-119, Philadelphia, 1926.
- ¹³ Petry, E.: Ueber die subkutanen Rupturen und Kontusionen des Magen-Darmkanals. Beitr. z. klin. Chir., vol. xvi, pp. 545-720, 1896.
- ¹⁴ Poland, A.: Contusion of the Abdomen. Guy's Hospital. Rep., vol. iii, series 1v, pp. 123-168, 1858.
- ¹⁵ Quain, E. P.: Subcutaneous Rupture of the Intestines, with Report of Twelve Cases. Jour. Lancet, vol. xli, pp. 71-78, 1921.
- ¹⁶ Rowland, R. P.: Subcutaneous Rupture of the Intestines. Brit. Med. Jour., vol. i, pp. 716-717, 1923.
- ¹⁷ Tschistossendorff, W.: Ein Beitrag zur Frage der Traumatischen subkutanen Darmruptur. Beitr. z. klin. Chir., vol. lxxix, p. 70, 1912.
- ¹⁸ Vance, B. M.: Subcutaneous Injuries of the Abdominal Viscera. Arch. Surg., vol. xvi, pp. 630-679, 1928.
- ¹⁹ Vance, B. M.: Traumatic Lesions of the Intestine Caused by Non-penetrating Blunt Force. Arch. Surg., vol. vii, pp. 197-212, 1923.
- ²⁰ Van Hook, W., and Kanavel, A. B.: Surgery of the Intestines. Keen's Surgery. W. B. Saunders Co., vol. iv, pp. 679-686, Philadelphia, 1910.

A STUDY OF MESENTERIC CYSTS*

WITH A REPORT OF TWO RECENT CASES

BY J. OGLE WARFIELD JR., M.D.

OF WASHINGTON, D. C.

IN AN attempt to bring the subject of mesenteric cysts up to date I have reviewed the literature since 1920 which included 129 case reports. There were probably an additional nine or ten cases, the articles of which were not available. I also submit two successfully operated cases from the records of the Children's Hospital.

History and frequency.—The first case was observed in 1507 by Benevieni, a Florentine anatomist, who accidentally found a mesenteric cyst at autopsy and characterized it as an anatomical curiosity. In 1803 Portal classified these cysts. Rokitansky in 1842 first described a chylous cyst at autopsy. In 1880 Tillaux successfully operated on a cystic mesenteric tumor. Pean in 1883 marsupialized such a tumor successfully and a little later Braumann, Kilian, Millard, and Marklen also treated similar cases surgically. In 1886 Augagneur found that eighteen out of ninety cases of mesenteric tumors were cystic. Arekion in 1891 referred to eighty-one case reports. In 1892 Braquehayé added twenty-three cases, thus making 104. Moynihan in 1897 added nine, and Dowd in 1900 added thirty-two, thus bringing the total published cases to 145. In 1906 Porter estimated the reported cases to be 200. Paskowski in 1912 collected thirty-one cases of dermoid tumors, twelve of which were in the mesentery of the large bowel and rectum, and a year later Mounier collected twenty cases of dermoid cyst of the mesentery. In 1912 Friend collected fifty-two cases of the chylous type and in 1913 Benedict supplemented this and brought the total to ninety-six cases of chylous mesenteric cyst. Carter in 1921 says there have been 200–300 case reports. Higgins and Lloyd in 1924 state about 250, and Flynn in 1930 judges 200–300 cases have been published.

Some writers have divided the history of these tumors into four periods: (1) 1507–1850, when the tumor was observed only at autopsy; (2) 1850–1880, when there was an occasional cyst found at operation, but no recoveries; (3) 1880–1900, when there were some cases of recovery after operation in which the cyst was accidentally found; (4) since 1900, when the condition was suspected and occasionally diagnosed.

Mesenteric tumors are the rarest tumors in the abdomen (Flynn, 1930). Of the true mesenteric tumors the cystic are four times more common than the solid neoplasms. Many text-books barely refer to the subject. A number of physicians of wide experience have neither operated nor seen a case. The majority of writers have been surgeons but a few were pathologists.

* Read before the Medical Society of the District of Columbia, December 16, 1931.

Most authors report a single case but several include two case reports and one author (DePena, 1924) recorded four cases.

It is difficult to estimate the number of reported cases to date. Up to 1900 there were 145 published cases and since 1920 I have reviewed 129 cases. It is fair then to judge that about 500 cases have been reported in the literature.

Etiology and classification.—Portal in 1803 first classified these tumors. In 1842 Rokitansky tried to prove their origin from degenerated lymph nodes. Braquehay in 1892 classified mesenteric cysts according to their contents and in 1897 Moynihan gave a similar classification and suggested the causes to be (1) hæmorrhage between mesenteric layers; (2) dilatation of lacteals or lymphatics; (3) degeneration of lymph glands. In 1900 Dowd divided these cysts according to their origin into (1) embryonic; (2) hydatid; (3) cystic malignant. He first noted the close embryonic relationship of the wolffian body and the root of the mesentery and suggested that sequestered cells from the wolffian body might be displaced forward into an intramesenteric position and later develop into a tumor. He also suggested that sequestered cells from the developing gut might likewise be displaced between the mesentery and develop into a cyst.

Writers since have amplified Dowd's classification and added additional ideas of the genesis of these neoplasms. Each writer has offered a new etiological classification so that to the reader it now becomes confusing. Among these writers I might mention Ayers (1906), Niosi (1907), Gould (1913), Miller (1913), Carter (1921), Bartlett (1923), Higgins and Lloyd (1924), Humiston and Pietti (1925), Hueper (1926), and Wilson (1929).

The causes of mesenteric cysts might be listed as follows:

(1) Embryonic retroperitoneal organs, as germinal epithelium, ovary, wolffian or müllerian bodies. Remnants of these organs become displaced forward between the mesenteric layers. Many of these neoplasms develop in this manner. The rare pararenal cysts probably originate from wolffian body remnants but retain their position and are not displaced into the mesentery. These cysts bear a close resemblance to the mesenteric cysts. Dermoids of the mesentery apparently arise from the ovary. No retroperitoneal nor mesenteric dermoids have been reported in the male though they have occurred in the testis (Ayers, 1906) which is originally a retroperitoneal organ. Swartley (1927) reports a sebaceous cyst in a male, twenty-six years, and Forster (1921) an epidermoid in a male, fourteen years. Both of these occurred in the jejunal mesentery but neither seems to have been a true dermoid so the fact that mesenteric dermoids always occur in the female and arise from the ovary still holds.

(2) Displaced embryonal intestinal tissue. Sequestrations from intestinal diverticula or from the vitelline duct become displaced between the mesenteric layers. In 1908 Lewis and Thyng described the regular occurrence of intestinal diverticula in embryos of the pig, rabbit and man and established the fact that the formation of diverticula and cysts is a regular occurrence

MESENTERIC CYSTS

in the embryonic development of the gut. Hence cysts from intestinal diverticula may occur anywhere along the bowel while those from the vitelline duct occur principally in the terminal ileum. Like the first cause many of these tumors also develop in this manner.

(3) Dermal inclusions. This origin was suggested by Bartlett (1923) but probably very few if any arise from dermal inclusions.

(4) Angiomas of blood and lymph vessels. This also includes but few of these cysts.

(5) Parasitic and bacterial infection. A few mesenteric cysts have originated from the echinococcus and from tuberculous abscesses.

(6) Necrosis of lymph glands or solid tumors, as tuberculosis, typhoid fever, lipomata, malignant tumors, *etc.*, is responsible for a few of these cysts.

(7) Trauma and foreign bodies. Hæmatoma from injury may degenerate to form a cyst. Usher (1926) reports such a case. Genkin (1928) removed a chylous cyst formed around a gauze tampon left in at a previous operation.

(8) Lymphatic obstruction. This possible origin of mesenteric cysts has practically been discarded. These lymphatic vessels anastomose so freely it is hardly conceivable that plugging of a chylous vessel would produce a cyst.

Cases are recorded at all ages from the foetus to the octogenarian but the fourth decade is most common. Women are affected twice as often as men. Very few are reported in the colored race.

Age	Cases	Sex	Cases
0-1	9	Female	71
1-10	21		
10-20	16		
20-30	18	Male	37
30-40	24		
40-50	17		
50-60	11	Unknown	21
60-70	3		
unknown	10		

Symptomatology and diagnosis.—There are no pathognomonic signs nor symptoms. The tumor is often too large or too small to accurately diagnose. Contrary to previous writers mesenteric cysts have been diagnosed before operation in a few cases, certainly since 1920 and probably before. Reports recording correct diagnoses are Haworth (1920), Bertolini (1921), Naumann (1921), Levinson and Wolfsohn (1926), Ciarlo (1927), Aloï (1927), and Finucci (1930). Others have suspected the condition.

An abdominal tumor which is rounded, smooth, not tender, cystic and quite mobile should suggest the probability of a mesenteric cyst. The mobility of the tumor is often striking and especially in the transverse direction,

due to its mesenteric attachment. Pain is more frequently present than with any other type of abdominal cystic tumor.

Other symptoms are due to the presence of some complication, principally intestinal obstruction. Hence a story of repeated attacks of abdominal pain sometimes with vomiting and alternating periods of diarrhoea and constipation is very important. The patient's weight may increase or decrease.

To repeat then, the symptoms may be those of a silent, cystic, abdominal tumor or those of intestinal obstruction. In the presence of rupture of the cyst or acute inflammation it is difficult to differentiate this condition from the other causes of an acute surgical abdomen. Hancock (1929), however, reports that he found at operation a ruptured cyst of the transverse mesocolon which had produced no acute symptoms.

Viadya (1927) reported a cyst of the ascending mesocolon which he only aspirated at operation and which filled again, and three weeks after the operation it apparently ruptured into the bowel for the patient passed quantities of liquid similar to the contents of the tumor and the distended abdomen became flattened.

In the differential diagnosis other conditions which must be considered are ovarian cyst, retroperitoneal tumors, pancreatic cysts, intestinal new-growths, pedunculated uterine fibroids, movable kidney, hydronephrosis, hydrops of the gall-bladder, ascites, tuberculous peritonitis, pregnancy, acute appendicitis, cholecystitis, intestinal obstruction, intussusception, perforated peptic ulcer, extrauterine pregnancy, ruptured pelvic or tubal abscess, acute peritonitis, acute pancreatitis, and acute diverticulitis.

To differentiate between the types of mesenteric cyst is practically impossible except on pathological examination.

Location.—Mesenteric cysts may occur anywhere along the intestinal tract from the duodenum to the rectum. Over half of the cases occur in the small bowel and one-fourth in the mesentery of the ileum. Of those in the large bowel the ascending, transverse and sigmoid colons share about equally.

Of the 129 cases reviewed I have listed the location of the cyst in order of frequency as follows:

Ileum	38	Appendix	2
Jejunum	14	Duodenum	1
Cæcum and ascending colon..	14	Gastro-hepatic mesentery	1
Transverse colon	13	Colon (portion unknown)	6
Sigmoid	12	Small bowel (portion un-	
Descending colon	5	known)	6
Duodeno-jejunal juncture	2	Unknown	15

Pathology.—These neoplasms may be so small that they cannot be palpated or so large that they practically fill the entire abdomen. The greater majority are single cysts, though a few are recorded of multiple tumors. About one-half of the cases are unilocular while the other half present two or more compartments. A duct connecting two cysts or a cyst and the intestinal lumen is said to have been described. (Hueper, 1926.)

The cyst wall is usually thin but varies in thickness and composition. The lining of these tumors is mostly epithelial though often destroyed by the internal pressure of the cyst. The epithelium is usually simple columnar, sometimes stratified and rarely ciliated. The structure of the cyst wall very often reveals the genesis of the neoplasm. The presence of primitive glomeruli demonstrate wolffian-body origin. Layers of smooth muscle, epithelium, and sometimes goblet cells establish intestinal tract etiology. An endothelial lining suggests the tumor arose from a lymphangioma. High columnar epithelium and pseudomucin or the presence of hair, teeth, *etc.*, indicate primitive sex-organ ancestry.

The contents of these tumors denote accidents that have befallen the cyst and only occasionally have any bearing on the etiology. The first classifications were based upon the cystic contents and included such terms as serous, lymphatic, lymphorrhagic, chylous, sanguinous and hæmorrhagic. The lymphatic and chylous cysts are about equally divided in number. The fluid may be clear, colorless, yellow, milky, mucinous, brown, sebaceous, or bloody. The reaction is alkaline, the specific gravity about 1.015 or 1.016. It often contains a large amount of albumin, cell débris, blood and cholestrin.

Malignant degeneration is rare and may be either carcinoma or sarcoma.

The case reports since 1920 might be classified pathologically as lymphatic or serous thirty, chylous twenty-eight, hæmorrhagic nine, dermoid six, malignant three, (one adenocarcinoma and two spindle-cell sarcoma), sebaceous two, epidermoid one, echinococcal one, unknown forty-nine.

Complications.—(1) Intestinal obstruction is the most frequent and most serious of the complications. It occurs in one-third of the cases and of these the mortality is 50 per cent. The obstruction is mechanical and includes intestinal narrowing or occlusion, kinking, volvulus, adhesions, and intussusception. Sala and Nachamie (1929) reported a case of prenatal volvulus of both the small and undescended large bowel and mention that two cases of prenatal volvulus of the small intestine had been reported in the past fifteen years.

Other complications occur only occasionally.

- (2) Peritonitis is a sequel to obstruction.
- (3) Hæmorrhage into the cyst has been fatal.
- (4) Rupture of the cyst into the peritoneum or into the bowel has caused death. This may occur spontaneously or be due to trauma.
- (5) Torsion of the cyst.
- (6) Impaction of the cyst in the pelvis causes symptoms depending on the organ upon which it presses.

Ordinary post-operative complications sometimes occur such as shock, pneumonia, dilatation of the stomach, post-operative hernia, recurrence of the cyst after incomplete removal, *etc.*

Prognosis.—The prognosis depends upon the size, location, site of attachments, time of diagnosis and operation, whether benign or malignant,

type of operation, presence of complications, age and general condition of the patient.

Treatment.—The treatment of mesenteric cyst is entirely surgical. In the acute cases the treatment is directed principally toward the complications, the chief one being intestinal obstruction, while in the subacute and chronic cases the operation consists of removing or obliterating the mesenteric cyst by one of several methods.

(1) Enucleation is undoubtedly the operation of choice, but it is not always feasible without injuring the bowel and hence each case must be studied at operation to determine the technic best adapted to the case at hand. This procedure is the one most often used and with the lowest mortality—9 per cent.

(2) Enucleation with intestinal resection is often necessary and has a mortality of 27.3 per cent. The enterogenous tumors usually cannot be separated from the intestine and require resection.

(3) Either drainage or marsupialization has been done in a number of cases and certainly has a place in the treatment of large, extensively adherent mesenteric cysts where enucleation even with resection is out of the question. The mortality of these two procedures in the reviewed series of cases was 16.6 per cent. This seems high and includes deaths due to complications. The mortality rate is better judged perhaps by the kind of complications present, size and location of the tumors, *etc.*, than by the type of operation employed. Marsupialization or drainage is rarely apt to result in a permanent sinus or recurrence which would ultimately require excision. The length of time of drainage varies from one to three months. Gurewic (1926) reports a cured case after marsupialization of a chylous cyst of the mesosigmoid that drained for one year. There have been several recurrences following drainage that afterwards have been enucleated.

(4) Aspiration may at times be helpful in diagnosis but should not be employed in the treatment of these tumors. It was often used by the older surgeons and there is an occasional case of recent years that has been aspirated.

The following table gives the types of operation used and results of the cases reported since 1920.

Operation	Cases	Cured	Recovered	Died	Res.	Unknown
Enucleation	56	42	..	5		9
Enucleation with resection...	22	14	..	6		2
Marsupialization	15	11	..	1		3
Drainage	5	2	..	3		..
Aspiration	4	..	3	1		..
Laparotomy	24	8	2	5		9
Autopsy	3	3		..

Of the twenty-four deaths the diagnosis before operation was obstruction in twelve, abdominal tumor in five, peritonitis in two, appendicitis in one, ectopic pregnancy in one, gall-bladder disease in one and unknown in two.

MESENTERIC CYSTS

The location of these cysts was jejunum eight, colon seven, (transverse four), ileum seven, duodenum one, and unknown one. Thirteen of the twenty-four deaths were in cases of five years or under, six were over thirty years and five between five and thirty years of age. The deaths were equally divided in sex.

CASE I.—White, male, six years, admitted to Children's Hospital, September 20, 1930.

History.—Swelling of the abdomen for three weeks. Appetite good, no constipation, vomiting, fever, night sweats nor urinary symptoms except enuresis. He was a full-term baby and breast fed for nine months. The only illnesses have been colds and at six months of age a diarrhoea which lasted several weeks. Both parents living and well. Three other children well. No tuberculosis in the family.

Examination.—Temperature 99.2°, pulse 100, respiration 26. Weight 42 pounds. The child was anæmic looking, thin, and with a greatly distended abdomen. Teeth in poor condition and tonsils enlarged. Heart and lungs negative. There was some chronic adenitis of cervical, axillary and inguinal nodes. The abdomen was symmetrically distended, tense, flat on percussion, cystic, with a flare at the costal margins and the skin stretched. No abdominal organs could be palpated and no tenderness, tumor mass nor rigidity was noted. Extremities negative. The blood on admission showed red blood cells 3,180,000, hæmoglobin 63 per cent., white blood cells, 6,700, lymphocytes 51 per cent., polymorphonuclears 49 per cent. (lobulated 45, bands 4). The urine was repeatedly negative. The Wassermann was negative (October 6). Röntgen studies revealed the heart enlarged to the left, thymus 34 per cent. Both diaphragms were displaced upward and the abdominal walls flared out; probably fluid in the abdominal cavity. The colon was negative. Several tuberculin tests were negative. Laryngoscopic examination showed hoarseness and redness of the vocal cords suggestive of tuberculosis. No tubercles were seen and smears were negative for the tubercle bacillus.

The impression was tubercular peritonitis and laryngitis, and diet, rest and ultra-violet therapy were advised. The child showed no progress. His weight increased 1 pound (43) but the abdomen became more distended; the blood-picture and hoarseness remained the same. The abdomen was tapped November 1, and November 25, 1930. Each time 20 cubic centimetres of bloody fluid was withdrawn, showing no growth on culture nor tubercle bacilli on smears. A laparotomy was finally decided upon.

Operation.—(By author) November 28, 1930. Avertin anæsthesia. A low mid-line incision revealed no free fluid. There presented a very large, dark-bluish, cystic tumor attached along the entire left lateral peritoneal wall, across the brim of the pelvis, bulging into the mesentery of the ascending and transverse colons and extending high up toward the liver and spleen where it was attached to the posterior peritoneum. It seemed to have two large cystic lobules, one toward the liver, and the other toward the upper left quadrant. The ascending and most of the transverse colon were seen to the right of and running across the upper portion of the tumor toward the left. The cæcum was fixed in the pelvis at or beneath the attachment of the cyst and was not seen. The small intestine was felt in the upper right quadrant and also seen after the cyst was opened. The ascending and transverse colon and small bowel were of normal appearance. The cyst was opened in the mid-line and contained bloody fluid. The cyst wall was thin and its lining smooth and shiny. This emptied only one lobule and a large lobule on the right was opened from the mesial side and underneath the ascending colon. There was possibly another lobule high up posteriorly that could not be reached but it was hoped this might communicate with the compartments already opened. The cyst wall was sutured to the anterior parietes and a rubber tube drain was placed in each lobule. About 1,900 cubic centimetres of bloody fluid was aspirated and approximately an equal amount spilled on the floor. Closure.

Laboratory Examination of the fluid revealed 1,900 cells per cubic millimetre. No pancreatic enzymes were present.

The temperature came down in a few days and the drainage was profuse. On the ninth post-operative day (December 7th), the temperature rose to 103° and became septic. The white blood cells varied from 18,000 to 20,000 with 85 per cent. to 90 per cent. polymorphonuclears and 18 to 25 band forms. The drainage changed to seropurulent and lessened. On palpation a large, tender mass appeared in the right side of the abdomen.

Second Operation.—December 24, 1930. Avertin anæsthesia. The sinus was explored with the finger and found to run up, back and to the left. The lobule on the right had closed but was opened and emptied of a large amount of foul, brown fluid. Six rubber drainage tubes were inserted.

His convalescence was long. The drainage was yellowish brown. The temperature slowly lowered but lasted for five weeks. The drainage tubes were very gradually shortened and removed six weeks after the second operation. Ultraviolet therapy helped considerably. His lowest weight was 32 pounds and on discharge (February 17, 1931) 41½ pounds.

On March 9, 1931, his weight was 45 pounds, red blood cells 4,600,000, white blood cells 8,000, hæmoglobin 75 per cent. The wound had healed and the abdomen was flat, symmetrical, soft, not tender, and there was no palpable mass. The hoarseness had improved.

Five months after operation (June 8, 1931) the boy looked well but pale. He played hard, had gained weight, ate well and the bowels were regular. The abdomen was flat without masses, tenderness or rigidity. The operative scar had widened and there was a separation of the recti muscles between which intestines protruded on straining.

He was seen November 11, 1931, about one year since operation. He is slender and pale but has been well and attending school. The recti muscles are separated ¾ inch below the umbilicus. Otherwise the abdomen is negative.

CASE II.—White, male, two and one-half years, admitted to Children's Hospital September 16, 1929. There were no symptoms. An abdominal tumor had been noticed at a baby show. Examination revealed a movable, cystic mass the size of a small grapefruit in the lower abdomen. The pediatrician (Doctor Copeland) made a diagnosis of mesenteric cyst. At operation (Doctor White) a serous cyst containing yellow fluid was enucleated from the mesentery of the small bowel. The convalescence was smooth and the child left the hospital in twelve days.

Summary.—The first case was observed at autopsy by Benevieni in 1507. Tillaux in 1880 successfully operated on a cystic mesenteric tumor. There have been approximately 500 cases reported to date. Dowd in 1900 classified these neoplasms according to their origin, which is chiefly embryonic from mesodermal remnants behind the developing peritoneum or from intestinal diverticula or persistent portions of the vitelline duct. There are no pathognomonic signs nor symptoms. One-half of these tumors occur in the small intestine and one-fourth in the mesentery of the ileum. The structure of the cyst wall varies with the origin of the tumor, while its contents have little bearing on the etiology. One-third of these cysts are complicated by intestinal obstruction in which the mortality is 50 per cent. The treatment consists of enucleation with or without intestinal resection, drainage, or marsupialization.

The two cases reported contrast the difficulty and simplicity of treat-

MESENTERIC CYSTS

ment. The first case reported illustrates the fact that the tumor was too large to diagnose correctly though the fluid removed at several tapplings should have been more completely examined. The operation of choice was certainly marsupialization due to the enormous size and extensive attachments of a multilocular cyst. I believe the tumor originated in the mesentery of the ascending colon. Unfortunately, a pathological section was not obtained and hence the etiology is not known. It was no doubt embryonic and possibly pressure from the growth had destroyed any definite pathology of the cyst wall. A second operation was necessary to establish adequate drainage which lasted for two and one-half months. The child was seen nearly one year after the operation and had a diastasis of the recti muscles but there was no evidence of a recurrence of the cyst.

BIBLIOGRAPHY

- ¹ Abadie and Argaud: *Bull. Acad. de méd.*, 3 S, vol. xc, p. 312, Paris, 1923.
- ² Alensen: *Calif. and West. Med.*, vol. xxx, p. 261, San Francisco, 1929.
- ³ Aloï: *Riforma med.*, vol. xliii, p. 1011, 1927.
- ⁴ Atchley: *Jour. Oklahoma Med. Assn.*, vol. xxii, p. 125, 1929.
- ⁵ Bani: *Riv. Ospedal Roma*, vol. xi, p. 87, 1921.
- ⁶ Bartlett: *S. Clin. No. Amer.*, vol. iii, pp. 811-821, 1923.
- ⁷ Bay and Wilkerson: *Am. Jour. Surg.*, vol. xxxvii, p. 309, 1923.
- ⁸ Becker: *Schweiz. med. Wchnschr.*, vol. lix, pp. 979 and 1006, 1929.
- ⁹ Benjamin: *Minn. Med.*, vol. x, p. 516, St. Paul, 1927.
- ¹⁰ Bertolini: *Osp. maggiore*, 3 S vol. ix, p. 278, 1 pl., Milano, 1921.
- ¹¹ Boge: *Klin. Wchnschr.*, (2nd Half), vol. i, p. 2579, 1922.
- ¹² Caeiro: *Bol. y trab. de la Soc. de cirug. de Buenos Aires*, vol. viii, p. 807, 1924.
 — *Semana méd.*, vol. xxxi, pt. 2, p. 1253, Buenos Aires, 1924.
- ¹³ Campbell: *Beitr. z. Klin. Chir. Tubing*, vol. cxxii, p. 165, 1921.
- ¹⁴ Candea: *Zentralbl. f. Chir.*, vol. xlix, p. 77, 1922.
- ¹⁵ Cappellani: *Clin. ostet.*, vol. xxx, p. 576, 1928.
- ¹⁶ Capponago: *Osp. maggiore*, 3 S, vol. xii, p. 101, Milano, 1924.
- ¹⁷ Carter: *Surg., Gynec. and Obstet.*, vol. xxxiii, p. 544, 1921.
- ¹⁸ Cerepnin: *Zentralorg. f. d. ges. Chir.*, vol. xxxv, p. 827, 1926.
- ¹⁹ Ceruti: *Riv. di chir.*, vol. i, p. 122, Como, 1922.
- ²⁰ Chaney: *Jour. Med. Assn., Georgia*, vol. xviii, p. 517, 1929.
- ²¹ Ciarlo: *Semana méd.*, pt. 1, vol. xxxiv, p. 1480, 1927.
- ²² Clark: *Am. Jour. Obstet. and Gynec.*, vol. xi, p. 238, St. Louis, 1926.
- ²³ Cornioley: *Lyon chir.*, vol. xxiii, p. 566, 1926.
- ²⁴ Dallera: *Folia gynæc.*, vol. xxvii, p. 197, 1930.
- ²⁵ DePena: *Arch. Latino-Am. de Pediat.*, 3 S, vol. xviii, p. 144, Buenos Aires, 1924.
- ²⁶ Derocque: *Normandie méd.*, vol. xxxii, p. 202, Rouen, 1921.
- ²⁷ Desgouttes and Ricard: *Jour. de chir.*, vol. xxxii, p. 269, 1928.
- ²⁸ Dowd: *ANNALS OF SURGERY*, vol. lxxiii, p. 784, Philadelphia, 1921.
- ²⁹ Dujarier: *Bull. et mém. Soc. anat. de Paris*, vol. xc, p. 48, 1920.
- ³⁰ Dutton: *New England Jour. Med.*, vol. cciii, p. 1032, 1930.
- ³¹ Einaudi: *Minerva med.*, vol. viii, p. 1023, 1928.
- ³² Elkin: *Bull. Soc. d'Obstét. et Gynéc.*, vol. xvii, p. 341, 1928.
- ³³ Elkin: *Semana méd.*, vol. xxxiv, pt. 2, p. 704, 1927.
- ³⁴ Elzas: *Nederl. Tijdschr. v. Geneesk.*, vol. i, p. 735, 1928.
- ³⁵ Fedeli: *Clin. Chir.*, vol. xxx, p. 953, 1927.
- ³⁶ Fedinec: *Bratisl. lekar. listy*, vol. ix, p. 245, 1929.

- ³⁷ Finucci: Policlinico (sez. chir.), vol. xxxvii, p. 506, 1930.
- ³⁸ Flynn: ANNALS OF SURGERY, vol. xci, p. 505, Philadelphia, 1930.
———Tr. South. Surg. Assn., vol. xlii, p. 241, 1930.
- ³⁹ Forster: Beitr. z. Klin. Chir. Tubing, vol. cxxiv, p. 116, 1921.
- ⁴⁰ Fumagalli: Osp. maggiore, vol. xv, p. 473, 1927.
- ⁴¹ Genkin: Arch. f. klin. Chir., vol. cli, p. 646, 1928.
- ⁴² Gey: Deutsch. Ztschr. f. chir., vol. cxcix, p. 341, 1926.
- ⁴³ Goedel: Zentralorg. f. d. ges. Chir., vol. xviii, p. 92, 1922.
- ⁴⁴ Green: Surg., Gynec. and Obstet., vol. xlv, p. 401, Chicago, 1927.
- ⁴⁵ Gueniot and Blum: Bull. Soc. d'Obstét. et Gynéc. de Par., vol. xv, p. 35, 1926.
- ⁴⁶ Gurewic: Zentralorg. f. Chir., vol. xxxiv, p. 33, 1926.
- ⁴⁷ Gurewitsch: Zentralbl. f. Chir., vol. lvi, p. 1358, 1929.
- ⁴⁸ Hancock: Kentucky Med. Jour., vol. xxvii, p. 206, 1929.
- ⁴⁹ Haworth: Lancet, vol. i, p. 1269, London, 1920.
- ⁵⁰ Higgins and Lloyd: Brit. Jour. Surg., vol. xii, p. 95, 1924.
- ⁵¹ Holeczy: Bratisl. lekar. listy, vol. v, p. 222, Praha, 1925.
- ⁵² Hubner: Presse méd., vol. xxxvii, p. 270, 1929.
- ⁵³ Hueper: Jour. Lab. and Clin. Med., vol. xii, pp. 427-430, St. Louis, 1926.
- ⁵⁴ Humiston and Pietti: Illinois Med. Jour., vol. xlvii, p. 93, Oak Park, 1925.
- ⁵⁵ Hunter: Brit. Med. Jour., vol. ii, p. 800, 1922.
- ⁵⁶ Jackson and Ewell: Wisconsin Med. Jour., vol. xxviii, p. 364, 1929.
- ⁵⁷ Joyce, Howard, Fitzgibbon: Northwest. Med. Jour., vol. xxix, p. 123, 1930.
- ⁵⁸ Kendall: Brit. Jour. Surg., vol. xviii, p. 168, 1930.
- ⁵⁹ Ladd: Am. Jour. Dis. Child., vol. xxxii, p. 701, Chicago, 1926.
- ⁶⁰ Lamb: Calif. and West. Med. Jour., vol. xxxi, p. 139, 1929.
- ⁶¹ Lang: Canad. Med. Assn. Jour., vol. xviii, p. 573, 1928.
- ⁶² Lapage and Morley: Lancet, vol. ii, p. 1116, 1925.
- ⁶³ Lardennois, LeRoux, and Leflaive: Ann. d'anat. pathol. méd. chir., vol. iii, p. 744, Paris, 1926.
- ⁶⁴ Larget and Cahen: Bull. et mém. Soc. anat. de Par., vol. xciii, p. 765, 1923.
- ⁶⁵ Lauterburg: Schweiz med. Wchnschr., vol. lx, p. 418, 1930.
- ⁶⁶ Lee: Med. Jour. Australia, vol. i, p. 83, Sydney, 1927.
- ⁶⁷ Le Moniet: Bull. et mém. Soc. nat. d. chir., vol. l, p. 897, Paris, 1924.
- ⁶⁸ Levin, Ellis, and Simson: Jour. Med. Assn. S. Africa, vol. i, p. 471, Capetown, 1927.
- ⁶⁹ Levinson and Wolfsohn: Calif. and West. Med. Jour., vol. xxiv, p. 480, San Francisco, 1926.
- ⁷⁰ Litinsky and Schiriak: Odessky Med. Jour., vol. iii, p. 8, 1928.
- ⁷¹ Markiwitz: Zentralbl. f. chir., vol. xlvii, p. 476, 1920.
- ⁷² Matassa: Studium Napoli, vol. xiii, p. 20, 1923.
- ⁷³ Mauclaire and Coulaud: Bull. et mém. Soc. anat. de Par., vol. xci, p. 288, 1921.
- ⁷⁴ Nandrot: Bull. et mém. Soc. chir. de Par., vol. xlvii, p. 563, 1921.
- ⁷⁵ Naumann: Arch. f. Klin. Chir. Berl., vol. cxvii, p. 819, 1921.
- ⁷⁶ Nigrisoli: Arch. Ital. di chir., vol. xiii, p. 170, Bologna, 1925.
- ⁷⁷ Nossen: Beitr. z. klin. Chir. Tubing, vol. cxxxii, p. 551, 1924.
- ⁷⁸ Novi: Policlinico, Roma, vol. xxviii, p. 503, 1921.
- ⁷⁹ Palmer: Jour. Med., Cincinnati, vol. viii, p. 239, 1927.
- ⁸⁰ Palmieri: Radiol. med., vol. viii, p. 140, Milano, 1921.
- ⁸¹ Pavoni: Gazz. Med. Napolet., vol. v, p. 165, 1922.
- ⁸² Payr: München med. Wchrschr., vol. lxvii, p. 1455, 1920.
- ⁸³ Peterson: Am. Jour. Surg., n. s., vol. v, p. 514, New York, 1928.
- ⁸⁴ Piccinelli: Policlinico, Roma, vol. xxxiii, sez chir, p. 322, 1926.
- ⁸⁵ Piermarini: Riforma med., vol. xli, p. 1224, Napoli, 1925.
- ⁸⁶ Polcenigo: Policlinico, sez prat, vol. xxxiii, p. 937, Roma, 1926.
- ⁸⁷ Raul: Bull. et mém. Soc. anat. de Par., vol. xciv, p. 644, 1924.

MESENTERIC CYSTS

- ⁸⁸ Righetti: *Riforma med.*, vol. xliii, p. 745, 1927.
- ⁸⁹ Roldan: *An. de Facul. de med.*, vol. x, p. 515, Montevideo, 1925.
- ⁹⁰ Romani: *Arch. Ital. di chir.*, vol. xiii, p. 161, Bologna, 1925.
- ⁹¹ Rotgans: *Nederl. Tijdschr. v. Geneesk.*, vol. i, p. 1684, Amsterdam, 1920.
- ⁹² Sala and Nachamie: *Arch. Path.*, vol. viii, p. 180, 1929.
- ⁹³ Saraceni: *Atti d. cong. ital. di radiol. med.*, vol. iii, p. 195, Milano, 1921.
 ——— *Radiol. med.*, vol. viii, p. 195, Milano, 1921.
- ⁹⁴ Schirmer: *München med. Wchnschr.*, vol. lxxxix, p. 108, 1924.
- ⁹⁵ Schurer and Waldheim: *Arch. f. klin. Chir.*, vol. cxl, p. 601, Berlin, 1926.
- ⁹⁶ Shallow: *ANNALS OF SURGERY*, vol. lxxxix, p. 795, 1925.
- ⁹⁷ Sofoteroff: *Zentralbl. f. Chir.*, vol. lii, p. 747, Leipzig, 1925.
- ⁹⁸ Sommer: *Beitr. z. klin. Chir.*, vol. cxxiv, p. 85, 1921.
- ⁹⁹ Strauli: *Zentralbl. f. Chir.*, vol. xlix, p. 1545, Leipzig, 1922.
- ¹⁰⁰ Sudhoff: *Arch. f. klin. Chir.*, vol. cxxix, p. 515, Berlin, 1924.
- ¹⁰¹ Swartley: *ANNALS OF SURGERY*, vol. lxxxv, p. 886, Philadelphia, 1927.
- ¹⁰² Tedenat: *Bull. et. mém. Soc. de Chir. de Par.*, vol. xlvii, p. 403, 1922.
- ¹⁰³ Tschistowitsch: *Zentralbl. f. allg. Path. u. path. Anat.*, vol. xlv, p. 132, 1928.
- ¹⁰⁴ Tugulea: *Zentralorg. f. Chir.*, vol. xix, p. 54, 1922.
- ¹⁰⁵ Usher: *Jour. Med. Assn. Georgia*, vol. xv, p. 179, Atlanta, 1926.
- ¹⁰⁶ Vaidya: *Indian Med. Gaz.*, vol. lxii, p. 81, Calcutta, 1927.
- ¹⁰⁷ Wade and Steigrad: *Med. Jour. Australia*, vol. i, p. 465, Sydney, 1928.
- ¹⁰⁸ Waugh: *Surg., Gynec. and Obstet.*, vol. xxxvii, p. 785, 1923.
- ¹⁰⁹ Westmann: *Zentralbl. f. Chir.*, vol. lii, p. 1931, 1925.
- ¹¹⁰ White: *Jour. Am. Med. Assn.*, vol. lxxiv, p. 440, 1920.
- ¹¹¹ Wilson: *Brit. Med. Jour.*, vol. i, p. 102, London, 1929.

MESENTERIC AND OMENTAL CYSTS*

BY EDWARD W. PETERSON, M.D.

OF NEW YORK, N. Y.

FROM THE SURGICAL DEPARTMENT OF THE NEW YORK POST-GRADUATE MEDICAL SCHOOL AND HOSPITAL OF COLUMBIA UNIVERSITY

It is the purpose of this paper to report five cases of mesenteric and one case of omental cyst, operated upon without mortality; to record a correct pre-operative diagnosis; and to offer a suggestion as to a method of surgical treatment, in selected instances, which, so far as I am aware, has not hitherto been proposed.

Since 1507, when Benevieni, a Florentine anatomist, found at autopsy and recorded it as an anatomical marvel, there have been published between 250 and 300 cases of mesenteric cysts. In 1852, Gairdner reported before the Pathological Society of London an autopsy specimen of an omental cyst, since which time there have been published slightly over fifty cases. The ratio of mesenteric to omental cysts is about 5 to 1. The two conditions are considered similar in origin and histological structure.

The theories of the older pathologists regarding the genesis of mesenteric cysts were clouded in obscurity and uncertainty. Such cysts were thought to result from "lymph stasis and from cystic degeneration of a lipoma or of tuberculous glands." Dowd's paper,¹ in 1900, was notable for its clearness and originality, and for the renewed interest in this subject which its publication aroused. He stated his belief that such cysts developed from embryonic remnants and sequestered intestinal tissue and he suggested that they be classified as (1) embryonic; (2) hydatid; and (3) cystic malignant disease.

Niosi,² in 1907, expressed the opinion that about one-half of all mesenteric cysts are acquired, and he placed the so-called lymphatic and chylous types in this category. He classified embryonic mesenteric cysts as:

- (1) Cysts of intestinal origin:
 - (a) By sequestration from the bowel during development.
 - (b) From Meckel's diverticulum, when it arises from the concave side of the bowel or (as Miller has added) acquires an intramesenteric position.
- (2) Dermoid cysts.
- (3) Cysts arising from retroperitoneal organs, *viz.*—urogenital organs (germinal epithelium, ovary, Wolffian body or Mullerian duct).

Eric Gould,³ in 1913, believed the following to be simplest and most correct pathological classification:

- (1) Cysts arising from embryonic remnants and sequestered tissue: (a) serous; (b) chylous; (c) sanguineous; (d) dermoids; (e) cysts from intestinal diverticula.

* Read before the Surgical Section of the New York Academy of Medicine, May 6, 1932.

- (2) Cysts of infective origin: (a) hydatids and (b) tuberculous abscesses.
- (3) Malignant cysts.

Higgins and Lloyd,⁴ in 1924, say that "such adjectives as lymphatic, chylous, sanguineous, though frequently used, merely denote accidents which may befall any cyst, and, though picturesque, they have no precise bearing on the problems of etiology and serve no useful purpose." Out of the mass of material studied, and the classifications reviewed, they offer these conclusions:

- (1) True mesenteric cysts are not malignant, parasitic or dermoid, but form a separate group in which are included the majority of all "mesenteric cysts."
- (2) Their origin is still in doubt, but it seems probable that there are two classes:
 - (a) Cysts of embryonic origin arising from mesodermal remnants incarcerated behind the developing peritoneum and subsequently migrating forward between its layers.
 - (b) Cysts of intestinal origin: (1) Arising in most cases as diverticula from the bowel during development; (2) possibly derived sometimes from persistent portions of the vitelline duct.
- (3) Anomalous and hitherto unclassified cysts, such as pararenal.

Mesenteric cysts occur somewhat more frequently in the female than in the male sex. They have been found at all ages—in the foetus and in an octogenarian. They may be single or multiple, unilocular or multilocular, and may vary in size from that of an olive to enormous growths filling the abdominal cavity. The original histological picture may be so altered from hæmorrhage, pressure, inflammation or malignant degeneration that it is difficult for the pathologist to render a satisfactory report as to the origin and structure of the cyst.

CASE REPORTS.—CASE I.—J. M., male, aged five years and ten months, of Italian parentage, was admitted to the Post-Graduate Hospital December 26, 1917, with a history of generalized abdominal pain, which had localized in the right lower quadrant, accompanied by nausea, vomiting and obstinate constipation.

Two years ago it was noticed that the boy's abdomen was growing larger and an exploratory operation a year later revealed a tuberculous peritonitis. The abdominal cavity was flushed out with full strength hydrogen peroxide and closed without drainage. It could not be learned from the history just what type of tuberculous peritonitis was found.

Physical examination was negative except for muscular spasm, resistance, and marked tenderness in right lower abdominal quadrant, and the presence of a very tender tumor mass. A diagnosis of acute appendicitis with abscess was made, and the patient was sent at once to the operating room.

On opening the abdomen the appendix was delivered, but failed to show any active inflammation. However, in the mesentery of the lower ileum, near the ileocolic angle, a cystic tumor, yellow in color, about eight by four by four centimetres in size, was found. Enucleation of the cyst could not be wholly accomplished, without sacrificing a relatively large blood-vessel, which was feared would result in gangrene of a small area of intestine. Rather than do a bowel resection, a small segment of the cyst wall, containing the blood-vessel, was left behind, the major portion of the cyst being removed. Carbolic acid followed by alcohol were applied to the remaining cyst membrane, which was then brought up to the abdominal incision, and the wound was closed in layers, except at a point where a narrow strip of iodoform gauze went down to the segment of the cyst wall left behind. Healing was prompt and without sinus formation or recurrence of the cyst. Patient was discharged two and one-half weeks after opera-

tion. An interesting observation at the time was the fact that there was absolutely no other evidence of the tuberculous peritonitis which had been found at operation a year before.

Pathological report (Dr. L. H. Meeker).—*Gross*.—Specimen is an opened sac, the size of a lemon. The surface is hæmorrhagic and at one side are thickened reduplications of peritoneum. The wall varies in thickness from $\frac{1}{2}$ millimetre to $\frac{3}{8}$ millimetre, is fibrous, and clinging to the inner side is caseous white granular material. At one point, beneath the entangled peritoneum, are small packets of this material. The wall is tough fibrous tissue.

Microscopical.—Under a capsule of dense fibrous tissue is an admixture of semi-necrotic areas of fibroblastic and epithelioid cells, coalescing and frequently showing giant cells of the foreign-body type. All this tissue is invaded by round cells and surrounds a caseous core. No normal grand tissue remains.

Diagnosis.—Probably cystic degeneration of a tuberculous lymph-node.

CASE II.—C. P., a woman, aged thirty-one years, married for fifteen years, but never pregnant, was admitted to the Post-Graduate Hospital, June 24, 1918, complaining of great weakness and fatigue, backache, abdominal discomfort, constipation, etc. Only three weeks before had she become aware of the presence of a large tumor in her lower abdomen. Although menstruation had been regular previously, for over a year there had been no menstrual flow. There was no appreciable loss of weight, in spite of two weeks' confinement to bed and a restricted diet.

Physical examination showed nothing of importance except a large, tense, symmetrical tumor in the lower abdomen, apparently rising out of the pelvis. The tumor did not move with respiration, was flat on percussion, and showed no pulsation. No foetal heart sounds could be heard. Vaginal examination showed the cervix crowded down to the vaginal introitus; the body of the uterus could not be mapped out. Rectal examination was negative, except for the presence of the large cystic tumor. *Diagnosis*.—Ovarian cyst.

When the abdomen was opened a large cyst was seen, with evidences of both old and recent active peritonitis. The coils of intestine were so adherent to the cyst that it could not be delivered or shelled out of its mesenteric bed. There was no connection whatever with the ovaries. The cyst was opened and a large quantity, probably over a gallon, of dark, straw-colored, serous fluid was evacuated. A section of the cyst was removed for histological study, then marsupialization and packing of the cyst cavity with washed-out iodoform gauze completed the operation. The first ten post-operative days were rather stormy. The profuse serosanguineous discharge necessitated frequent changes of dressing. The discharge rapidly lessened and the patient returned to her home three and one-half weeks after operation. The sinus was entirely healed at the end of three months, and the patient has remained well, without any abdominal complications since.

Pathological report (Dr. L. H. Meeker).—*Gross*.—Specimen is a portion of a cyst wall roughly seven by two centimetres. One side is fairly smooth and the other is granular and hæmorrhagic. One wall is several millimetres thick and is very tough.

Microscopical.—The cyst wall is composed of layers of fibrin with few fibroblasts and scattered blood-vessels, and some round cells. One-half its thickness presents a classical picture of foreign-body giant cells which have ingested cholesterin crystals. It would seem that adhesions have created a cyst the contents of which included cholesterol. *Diagnosis*.—Simple cyst within adhesions.

CASE III.—S. C., male, aged six years, of healthy Italian parentage, was admitted to the Babies' Wards, Post-Graduate Hospital, April 28, 1927. At fifteen months of age the boy had had, in the order named, measles, whooping-cough, pneumonia and multiple furuncles, from which he made a good recovery. At four years of age, it was noticed that his abdomen was somewhat larger than normal, but otherwise he seemed perfectly well. Three weeks before admission there developed an acute attack of ab-

dominal pain, with high fever, vomiting and constipation, but the attack subsided after three or four days. No definite diagnosis was made at this time. Upon admission, the examination revealed an irregular enlargement of the abdomen and an acute right-sided epididymitis. A large, movable, nodular, tense, cystic mass, occupying the right side of the abdomen and extending over beyond the median line, could be felt. In the left upper abdomen there was distended tympanitic bowel.

May 6, 1927, the abdomen was opened and the tumor mass was found to be a large cyst and two smaller cysts of the mesentery, grouped together and intimately connected with the lower ileum. It could be lifted out of the abdomen easily. An attempt was made to enucleate the cysts from the mesentery but it was found impossible of accomplishment, without sacrificing the blood supply to the bowel. It was necessary to resect about eight inches of intestine in order to remove the tumors. An end-to-end suture anastomosis of the ileum was performed without difficulty. The patient made a prompt and uninterrupted recovery and was able to leave the hospital two weeks after operation.

Pathological report (Ward J. MacNeal, M.D.).—*Gross*.—Specimen measured 160 by 115 by 80 millimetres. It included a portion of intestine, apparently the small intestine, 110 millimetres long and ten to twenty-two millimetres in diameter. Intimately attached at one side of this piece of gut there were three cysts; one was sixty millimetres, another thirty-five millimetres, and the other 120 millimetres in diameter. These were opened. The wall of the cysts in each case was about one and one-half millimetres thick.

Microscopical.—Sections through the wall of the intestine including the wall of one of the adjacent cysts showed moderate inflammatory reaction in the mucous membrane of the gut and some thickening of the muscular coats. The cyst was lined by granulation tissue in which there were abundant clefts from which lipoid material had been dissolved out. In this granulation tissue there were abundant multinucleated giant cells of the foreign-body type. The superficial portion of the lining was necrotic. It was impossible to recognize any elements of intestinal mucous membrane in the lining of the cyst in these sections. *Diagnosis*.—Multiple cysts of the mesentery intimately attached to the small intestine, of unrecognized origin.

Dr. Nicholas M. Alter later examined the specimen and reported as follows: "The description by Doctor MacNeal fits the microscopical picture accurately. I do not think the cyst is of intestinal origin or derived from the omphaloenteric duct. I think it should fall in Gould's classification (Group I), of embryonic cysts of chylous origin. In the lower layer of the cyst wall there are very numerous dilated lymph-vessels and chylous cells are seen in many of these dilations."

CASE IV.—S. S., a man, aged fifty-nine years, born in Russia, was admitted to the Post-Graduate Hospital, October 15, 1929, complaining of gradual loss of weight (15 pounds) and strength, increasing constipation with subacute attacks of intestinal obstruction. Appetite poor, digestion fair, some nausea, but no actual vomiting. No blood or pus in stools. Symptoms began about six months ago. After an X-ray study of the gastro-intestinal tract, in a Brooklyn Hospital, a diagnosis was made of "carcinoma of the ascending colon."

The general physical examination revealed nothing of importance. Abdominal examination showed considerable tumefaction on the right side, about opposite the umbilicus, and the diagnosis of carcinoma of the colon seemed probable.

Upon opening the abdomen a large, hard mass was at once encountered, but it involved the ileum and not the large intestine. Coils of ileum were adherent about this tumor, which was thought to be a new growth in the ileum, with extensive metastasis in the mesentery. The involved bowel and mesentery were widely resected, followed by an end-to-end suture anastomosis. The patient stood the operation well, but his convalescence was unusually stormy and exciting. He finally made a good recovery, except for an incisional hernia.

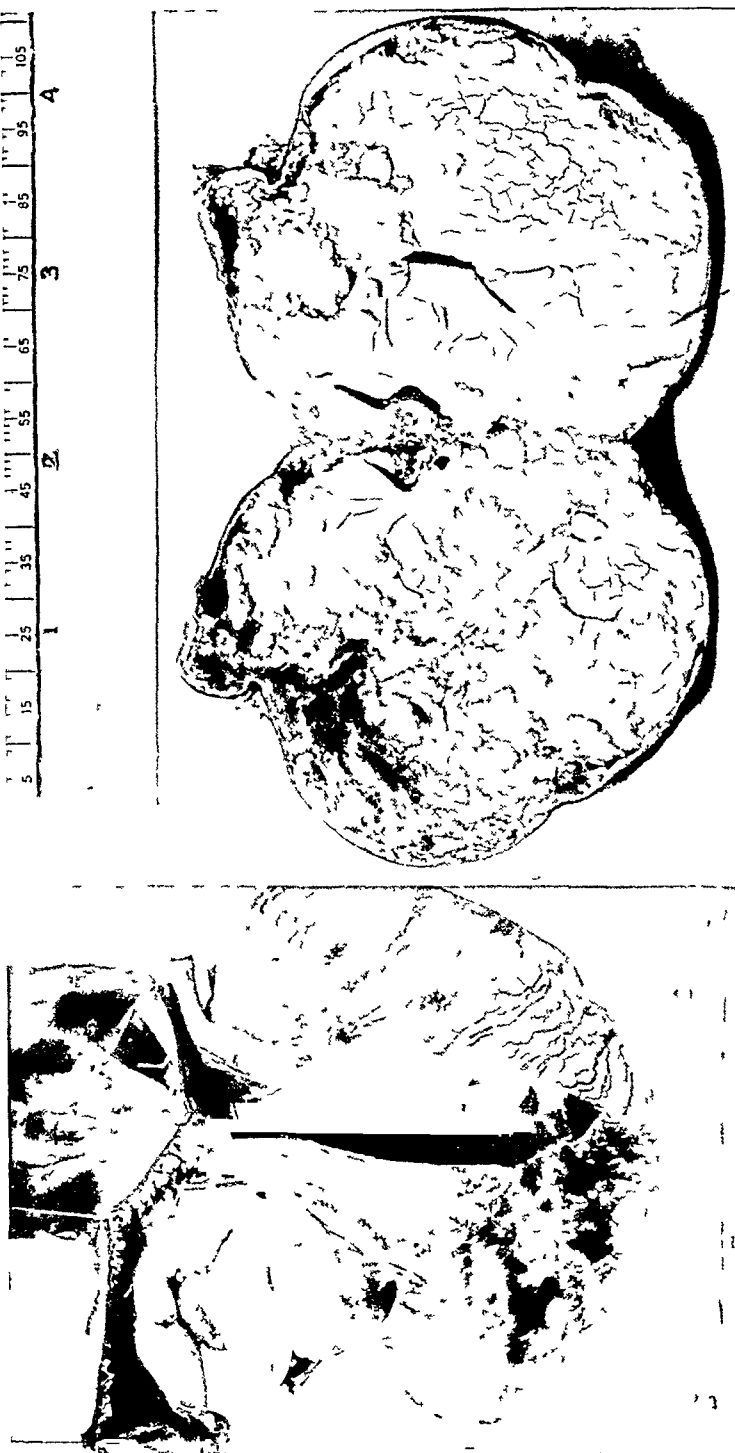


Fig. 1.—Case III Multiple cysts of the mesentery
Note narrowing of intestine from pressure

Fig. 2.—Case V Mesenteric cyst filled with thick sebaceous material Two
smaller cysts had similar contents

MESENTERIC AND OMENTAL CYSTS

Pathological report (Dr. Nicholas M. Alter).—*Gross*.—Specimen consists of a large portion of the small intestine with mesentery attached. It measures 280 centimetres (about nine and one-half feet) in length. The loops of the small intestine are moderately distended and are firmly adherent to a central mass which seems to come up from near the ileum about fifteen centimetres from the surgical stump of the ileum and from this extends into the mesentery which is adherent to the other loops of the intestine. This mass is very hard in consistency and measures about ten centimetres in diameter. On opening no obstruction is encountered. The lumen of the ileum is free. From the ileum a cystic cavity is opening which has an orifice six centimetres in diameter. This leads into a somewhat larger cavity which contains a great deal of greenish vegetable matter, a large amount of mucus and broken-down necrotic material and the wall is covered with a polypoid growth which is very hard at the base and on section shows gray translucent appearance. The growth is very hard, cartilaginous almost.

Microscopical.—Section of the growth shows neoplastic proliferation of small polygonal cells with large vesicular nuclei. The cells are quite anaplastic, show great variety of size and shape and form a rather diffuse growth. There is a suggestion only here and there of glandular structures and there is a vascular stroma. The growth ulcerates over the mucosa and infiltrates the muscle layer but has a rather sharp border.

Diagnosis.—Embryonal carcinoma of mesenteric cyst.

January 14, 1932, two and one-quarter years after the operation already described, the patient was operated upon for the repair of the incisional hernia. Upon exploration of the abdomen the exact site of the anastomosis could not be determined, so perfect was the union, and it is gratifying to report that there was absolutely no evidence of recurrence of the malignant disease.

CASE V.—Mrs. E. G., twenty-six years of age, was seen in consultation with Dr. A. A. Weiss, of this city, April 10, 1930. Three or four days before she had complained of abdominal pain, which had localized in the right lower abdomen. The pain was not severe, but as it persisted, the family physician was called. There was some nausea, but no vomiting. Bowels, usually regular, were constipated. There was only slight elevation of temperature, the urine was negative, and a blood examination showed some increase in the total leucocytes and the percentage of polymorphonuclear cells. The patient has always considered herself an exceptionally healthy individual.

The physical examination was negative except for rather marked tenderness over McBurney's point, with some muscular spasm and resistance. In the course of the examination, however, a rounded, freely movable, non-tender tumor was discovered, just to the right of and below the umbilicus. When questioned about it the patient said that she had known of its presence since she was sixteen years of age, but as it had never caused her any inconvenience whatever, it gave her no concern. She entered Post-Graduate Hospital that night and was operated upon early the following morning.

The abdomen was entered through a pararectus (Kammerer) incision. The appendix was readily delivered and removed. The ileum was then pulled up and a tumor mass consisting of three mesenteric cysts in the lower ileum was delivered. These cysts were carefully enucleated from the mesentery, without any damage to the blood supply of the bowel. The openings in the mesentery were closed with plain catgut sutures. The immediate clinical diagnosis was recorded as "subacute appendicitis" and "dermoid cysts (3) of the mesentery." One of the cysts was opened during its removal and was filled with thick sebaceous material. Although no hair or bone was discovered the contents of the cyst looked typical of the usual material found in dermoid cysts.

Following operation the patient suffered considerable nausea, vomiting, and abdominal discomfort for two or three days, after which time she made an unusually smooth convalescence, and was able to leave the hospital on the ninth post-operative day. Her health has been perfect since the operation.

Pathological report (Dr. W. J. MacNeal).—*Gross*.—Appendix is fifty-six millimetres long and seven to eight millimetres in diameter. On section the lumen extends to the

tip. In it there is one very firm lump ten by four by three millimetres, dark brown in color, apparently a fecolith.

Second specimen appears to have been a cyst about thirty millimetres in diameter with a wall one to two millimetres in thickness, rather firm. The material in the interior is in part soft cheesy stuff and in part is calcified.

Third specimen is a cyst seventy-two by sixty by forty-six millimetres. This is said by Doctor Peterson to resemble the cyst which has been broken open and this second cyst is left intact by his request.

Microscopical.—Sections of the appendix show partial loss of lining mucous membrane with purulent exudate extending into the submucous layer in the regions of ulceration. The muscular coats and the subserous coat are very œdematous and richly infiltrated by lymphocytes and plasma cells with smaller numbers of polymorphonuclear leucocytes intermingled.

Sections of the wall of the opened cyst show a lining of necrotic material beneath which there is a zone of epithelioid cells containing occasional poorly defined multinucleated giant cells and intermingled with lymphocytes. External to this there is a layer of fibrous tissue containing abundant lymphocytes and at one place a small nodule of epithelioid cells suggesting a small tubercle.

Diagnosis.—(1) Acute purulent exacerbation of a chronic appendicitis; subacute peri-appendicitis. (2) The diagnosis is somewhat uncertain, as tubercle bacilli have not been demonstrated in the cyst. However, the diagnosis of tuberculosis seems most probable.

OMENTAL CYST.—CASE I.—J. B., aged four years, admitted to Post-Graduate Hospital, February 27, 1921, complaining of abdominal pain and fever, but no vomiting. Bowels had moved normally the day before. Patient looked sick. Lips covered with fever blisters. Had previously had measles and chicken-pox. When fourteen months old had been operated upon for mastoid trouble.

Physical examination negative except for slight distension, marked tenderness and board-like rigidity over the whole lower abdomen. It was not possible to make a satisfactory examination without giving an anæsthetic. *Impression.*—Acute appendicitis with peritonitis. Patient sent at once to operating room for emergency operation. Upon entering the abdomen a cystic tumor mass, in the large omentum, was recognized at once. The appendix showed no gross pathology, but was removed as a prophylactic measure. The cyst-bearing omentum was resected with ease. The patient made a prompt and uninterrupted recovery.

Pathological report (Dr. Nicholas M. Alter).—*Gross.*—Specimen consists of a cystic mass with some fatty tissue attached, evidently portion of the omentum. The mass is lobulated, cystic, well encapsulated. Some of the cysts are evidently leaking clear serous fluid. The mass measures about 11 by eight by four centimetres. On section multilocular cavities are seen filled with yellowish jelly-like material and some white membranes. Otherwise the cysts seem to have smooth but congested lining. The wall of the cyst averages two to three millimetres and is fibrotic. The outer surface is covered with fibrous and fatty tags.

Microscopical.—Section shows some endothelial lining of the cyst. The endothelial cells are quite hyperplastic in many places. The surface is covered with some mucoid fibrinous material which contains a great many polymorphonuclear leucocytes. These polymorphonuclear leucocytes also infiltrate the entire wall which otherwise consists of loose fibrous structure.

Diagnosis.—Congenital peritoneal cyst of omentum with acute secondary infection.

Comment.—Omental cysts are similar in origin and structure to mesenteric cysts. The surgical treatment is, as a rule, a very simple matter and the mortality in the reported cases said to be about 6 per cent. The symptoms in my case were caused by inflammation of the cysts and local peritonitis.

SUMMARY.—*Symptoms and diagnosis.*—In the first case the symptoms were typical of acute appendicitis, *viz.*, abdominal pain, general in character at first, later localizing in the right lower quadrant, nausea, vomiting and constipation, with muscular rigidity and spasm and marked localized tenderness. Pre-operative diagnosis—acute appendicitis with abscess; post-operative and pathological diagnosis—cystic degeneration of a tuberculous lymph-node.

In the second case the symptoms of weakness and fatigue, backache, abdominal pain, constipation, and the downward displacement of the uterus, were caused by peritonitis and pressure. The preliminary diagnosis of ovarian cyst was incorrect. The pathological diagnosis of simple cyst due to foreign body (?), or gauze sponge from previous operation (?) is incorrect too, for the patient had undergone no previous operation. This is believed to be one of the rare, intraperitoneal cysts, of *nephrogenic* origin, in Group III, of Ewing's classification.* These cysts occur chiefly in adult women, are of large size, single or multilocular, involve the mesentery or adjacent regions or extend into the pelvis. The contents are brownish, serous fluid, containing pseudomucin.

In the third case the symptoms were of chronic intestinal obstruction, due to pressure-narrowing of the bowel by the cysts. (Intestinal obstruction, either acute or chronic, is the most important and frequent complication of mesenteric cysts. It may be from volvulus, intussusception, kinking and pressure-narrowing or occlusion of the adjacent intestine. Other complications are (1) hæmorrhage into the cyst, (2) torsion of the cyst, and (3) rupture of the cyst. In this case the diagnosis should have been made. Practically everything but mesenteric cyst was considered and it was not even thought of. The pathological diagnosis was embryonic mesenteric cyst of the chylous type.

In the fourth case the symptoms were of chronic intestinal obstruction, with subacute exacerbations. The preliminary diagnosis of a malignant growth of the intestine, causing obstructive symptoms, was again wrong. The pathological diagnosis of "carcinoma of an embryonal mesenteric cyst" places the case in a most remarkable and unusual class. Cystic malignant disease of the mesentery is not uncommon, but malignancy developing in an embryonic mesenteric cyst is both interesting and rare. Doctor Alter's microscopical report stating "the growth ulcerates over the mucosa and infiltrates the muscle layer" and the further observation that there was an opening from the ileum into the cyst, would make it highly probable that it was an enterogenous cyst, which had undergone malignant degeneration.

In the fifth case there were no symptoms whatever attributable to the mesenteric cysts. During an examination of a patient suffering from an attack of acute appendicitis, a movable, tense, cystic, non-tender abdominal

* Dr. James Ewing was kind enough to review the case histories and pathological reports in this series of cases. In Case II, he agreed that the mesenteric cyst was probably of nephrogenic origin.

tumor was felt. The patient had known of its presence for a number of years. A pre-operative diagnosis of mesenteric cyst was made and recorded, and on the following day was confirmed at operation. A tumor mass, consisting of three mesenteric cysts in the lower ileum, was delivered and the cysts enucleated. The clinical diagnosis was *dermoid cysts* of the mesentery, but the pathologist, Doctor MacNeal, while not positive, says they are probably tuberculous.

Treatment.—The treatment of mesenteric cysts can be considered under the following headings: (1) Enucleation; (2) resection; and (3) drainage.

(1) *Enucleation.*—This is the ideal operation and should be the method of choice when and where it can be accomplished without damage to the bowel or to the vascular supply thereof. From a study of the reported cases it is probable that this procedure is applicable in about one-third of all cases. Flynn gives the mortality following this operation at about 16 per cent. Enucleation could be done in but one of my cases.

(2) *Resection.*—By resection is meant the extirpation of the cyst or cysts and the resection of the involved bowel, with the establishment of some type of intestinal anastomosis. This operation is called for often—probably in one-fourth to one-third of the cases encountered. Unfortunately the mortality following resection is high—about 60 per cent. This can be explained by the fact that many of the emergency operations in which it is done are performed for the relief of acute intestinal obstruction, or in the presence of acute peritonitis. It is indicated when a successful enucleation cannot be completed and when marsupialization—drainage does not relieve or is apt to be followed by intestinal obstruction. Resection was performed in two, or 40 per cent, of my cases.

(3) *Drainage.*—When the size of the cyst or dense intestinal adhesions or other complications make the removal of the tumor a dangerous procedure, then some form of drainage of the cyst is called for. Simple wick or tube drainage is, in my opinion, inferior to gauze packing of the cyst cavity. Carter, Swartley, and others consider marsupialization obsolete, save in very exceptional instances. Flynn thinks it applicable only in parasitic cysts or in large unilocular cysts where the removal of the tumor is extremely hazardous. Despite the immediate theoretical dangers (of infection, peritonitis, intestinal obstruction) and the possible remote complications (recurrence of the cyst, persistent sinus, hernia, late intestinal obstruction, *etc.*) a study of the many isolated cases—reports in which this method was used, with both early and late good results—is convincing proof that the objections to it are more fanciful than real. It should never be employed in dermoid cysts nor as a make-shift or “way out” when enucleation can be accomplished or when resection is indicated. It is relatively safe and simple, with a mortality of only about 6 per cent., and a morbidity that is surprisingly slight. The gratifying outcome in my second case, in which no other plan of treatment seemed feasible, is offered as evidence of its value.

MESENTERIC AND OMENTAL CYSTS

Is there no other plan of surgical treatment to be employed, when enucleation cannot be done; when resection, with its high mortality, should be avoided; and when drainage, with its protracted convalescence, is deemed inadvisable? It is fully realized that such cysts as sebaceous, dermoid, including the piloninal variety, hygromatous cysts, mid-line and lateral embryonic cysts of the neck, *etc.*, require complete extirpation, otherwise there will be recurrence of the cyst or a persistent sinus will follow. Such half-way measures as incision, cauterization, packing or incomplete removal of the cyst will practically always result in failure to effect a cure. On the other hand there are many types of simple cyst that will heal after ordinary drainage operations. A most striking example can be cited in simple, uncomplicated hydrocele of the tunica vaginalis. Aspiration-injection, marsupialization-drainage, and resection or eversion of the hydrocele sac are methods that have been and still are being used in the successful treatment of this condition. It is my belief (based on my experience in my first and second cases of mesenteric cyst), in selected instances of single, thin-walled, serous, sanguineous or chylous cysts, the removal of the greater part of the cyst membrane, with closure of the incision in the mesentery, bringing the remaining segment of cyst in contact with the raw surface of the mesentery—that it will prove to be a perfectly satisfactory operation. It could be modified by placing a simple wick or cigarette drain into the intramesenteric space, from which the cyst was removed, but the first suggestion, of closure without drainage, is believed to be a better one.

CONCLUSIONS.—In June, 1927, the excellent article of Swartley, of Philadelphia, was published, giving a comprehensive review of the whole subject and bringing up-to-date the most recent opinions on the genesis, classification, diagnosis, and management of mesenteric cysts. Before his paper appeared I had stumbled upon three such cases and had operated upon them without ever having considered the possibility of such a surgical condition. The text-books consulted at that time gave little or no information on the subject, and the same is largely true today.

The impressions gained from my own experience and from a rather extensive study of the literature on mesenteric cysts are:

(1) If all the cases met with in practice could be put on record, the condition would no longer be considered rare—only relatively rare.

(2) Unless teachers of surgery make occasional mention of and unless future works on surgery place more emphasis upon this topic, failures to make correct pre-operative diagnoses will continue to be the rule and surgical mortality and morbidity will remain unnecessarily high.

BIBLIOGRAPHY

- ¹ Dowd: *ANNALS OF SURGERY*, vol. xxxii, pp. 515-542, 1900; and vol. liv, pp. 617-624, 1911.
- ² Niosi: *Virchow's Archiv. f. path. Anat.*, vol. cxc, pp. 217-338, 1907.
- ³ Gould: *Brit. Jour. Surg.*, vol. iii, pp. 42-47, 1913.
- ⁴ Higgins, and Lloyd: *Brit. Jour. Surg.*, vol. xii, pp. 95-105, 1924.

SODIUM RICINOLEATE

ITS POSSIBLE VALUE IN THE PREVENTION AND TREATMENT OF PERITONITIS

By SAM F. SEELEY, M.D.

CAPTAIN, MEDICAL CORPS, U. S. ARMY

OF MANILA, P. I.

THE value of soaps as germicidal agents has been frequently stressed. According to Walker,¹ "Koch first found that soap solutions possessed germicidal properties. Koch did not use chemically pure soaps, commercial soaps only being utilized. The first systematic work with chemically pure soaps was done by Reichenbach, who found potassium stearate, palmitate and myristate were germicidal to *Bacillus coli*." Walker found that pneumococci and streptococci were easily killed by sodium laurate and that while *Bacillus typhosis* was somewhat resistant, *Streptococcus aureus* was little affected by this soap. Nichols² showed that 0.5 per cent. sodium oleate, sodium resinate or "brown soap," in dish water, killed *Streptococcus pyogenes*, *Bacillus influenzae* and pneumococcus. Reasoner³ showed that shaving soap lather killed *T. pallidum* immediately. Walker⁴ found cocoanut oil soap to be germicidal to *Bacillus typhosis* when used in washing hands. Tilley and Schaffer⁵ found the germicidal ability of cocoanut oil to be increased by the addition of sodium chloride. Page and Allen⁶ found that repeated intraperitoneal injections of soap solutions produced pathological changes, usually mild, and probably in a large degree non-specific. Recently, a highly purified soap, sodium ricinoleate, has been found to be bactericidal, inhibitory to bacterial growth and to be effective in detoxifying many toxins and endotoxins. These toxins while rendered non-toxic, are not destroyed, and in combination with the soap they retain antigenic properties that make them valuable in producing active immunization. It is the purpose of this paper to review the work with sodium ricinoleate and to point out some of its properties that may make it of value in its use in the prevention and treatment of peritonitis.

Larson and Montank,⁷ in 1923, studying the effect of wetting on the viability and pathogenicity of the tubercule bacillus, noted that cultures grown in media containing sufficient sodium ricinoleate to depress the surface tension to 44 dynes were not so virulent to guinea-pigs as cultures grown under ordinary conditions. This prompted them to investigate the effect of 2 per cent. sodium ricinoleate on the pathogenicity of tubercule bacilli in sputum. Equal parts of 2 per cent. sodium ricinoleate and sputum containing tubercule bacilli which had stood for several hours after mixing, when injected into animals caused only a local lymphadenitis that subsided in fourteen days without any signs of tuberculosis. Controls injected with half the volume of untreated sputum all died.

Larson and Nelson⁸ then discovered that sodium ricinoleate completely detoxified tetanus toxin and diphtheria toxin. Guinea-pigs were not affected by one hundred lethal doses of the respective toxins when the soap was added. This caused Larson, Evans and Nelson⁹ to study the value of soap-toxin mixtures as antigens. Rabbits and guinea-pigs treated with soap-toxin mixtures were rendered immune and the serum of rabbits

SODIUM RICINOLEATE IN PERITONITIS

was found to have a high titre of antibodies against tetanus toxin. Guinea-pigs were immunized against both tetanus toxin and diphtheria toxin. They made the important observation that toxins were not only detoxified, but that their antigenic properties were not affected by sodium ricinoleate. Larson and Nelson¹⁰ later found that if a solution of sodium ricinoleate was added to a virulent culture of pneumococcus, so that the final dilution of soap was 0.1 per cent., the microorganisms lost their pathogenicity instantly. Twenty-four hours after the intraperitoneal injection of such a mixture into rabbits, large amounts of agglutinins were present in the blood-stream, and the animals were resistant to many times the lethal dose of pneumococci. The serum of rabbits thus immunized protected normal rabbits against intraperitoneal and intravenous infections. A strain of *Streptococcus scarletinae* lost its power to grow upon culture media when treated with 0.5 per cent. sodium ricinoleate for less than five minutes. Streptococci thus treated produced agglutinins in rabbits within twenty-four hours after intraperitoneal injection.

Larson and Colby¹¹ then prepared scarlet toxin, the potency of which was 15,000 skin doses per cubic centimetre, and added sodium ricinoleate so that the final dilution of the soap was 1 per cent. Very encouraging results in immunization of children against scarlet fever were obtained with the intramuscular injection of varying amounts of this solution. Ninety-six per cent. of 132 children gave a negative Dick reaction three weeks after they had received a single dose. A mild local reaction followed the injection in 15 per cent. of these cases. Larson, Hancock and Eder¹² reported successful immunization of children against diphtheria by mixtures of sodium ricinoleate and diphtheria toxin. Larson and Eder¹³ later reported on immunization against diphtheria and concluded that the mixture of soap and toxin was superior to that of toxin-antitoxin and also that it had the additional advantage of eliminating horse serum. Larson, Huenekens and Colby¹⁴ then reported the further use of sodium ricinoleate and scarlet-fever toxin in immunization. The fact that 77.3 per cent. of those treated were negative to skin test after eight days suggested the use of the mixture in suppressing an epidemic of scarlet fever.

In the earlier paper of Larson and Colby¹¹ 48 per cent. of cases receiving a single dose gave a negative skin test after five days. Since this time large numbers of children have been thus successfully immunized against scarlet fever and diphtheria by the use of three injections at seven-day intervals. During 1927 Larson and his assistants successfully immunized children against scarlet fever and diphtheria by using a mixture of the toxins of both scarlet fever and diphtheria and sodium ricinoleate. Three doses at weekly intervals were given. Since that time Larson has immunized several thousand children against these diseases. Other workers have reported similar success.

Carmichael¹⁵ interested in the toxic properties of ricin, a powerful vegetable toxin, found that 200 lethal doses of ricin, to which was added 0.4 grams of sodium ricinoleate, was rendered non-toxic to laboratory animals. Immunity to ricin developed after a single injection of the soap-toxin mixture. He also noted that the sera of animals treated with soap-toxin mixtures had antiricin properties. Carmichael¹⁶ further found that five lethal doses of rattlesnake venom was rendered non-toxic to rabbits when treated with sodium ricinoleate *in vitro*. He also detoxified rattlesnake venom by leaving the needle at the site of injection and introducing sodium ricinoleate thirty minutes later.

McKinley and Larson¹⁷ obtained a sample of the "M. A." strain of poliomyelitis and produced poliomyelitis in monkeys. Monkeys thus affected were killed at the height of the disease and an emulsion of brain tissue was prepared in 1 per cent. sodium ricinoleate. This solution produced active immunity in normal animals. Although their series was small the authors concluded that it demonstrated a possible method of immunization against poliomyelitis.

Netter, Andre, Cesari and Cotoni¹⁸ in France, confirmed Larson's findings of the effect of sodium ricinoleate on the organisms of anthrax, tuberculosis, and on the toxins of *Bacillus tetani*, *Bacillus diphtheriae* and *Streptococcus scarletinae*. Netter, Coshni and Cotoni¹⁹ confirmed Larson's findings on the effect of sodium ricinoleate on the toxins

of streptococci and pneumococci. Cotroni and Cesari²⁰ and Renaud,²¹ reported further on sodium ricinoleate.

Halvorsan,²² in 1925, reported the method used by Larson in preparation of his soap. Kozlowski²³ attempted to substantiate Larson's findings, using a solution of sodium ricinoleate that he had prepared, and concluded that the soap was too toxic for clinical use. He produced ulceration at the site of injection and killed a large number of mice with solutions that contained 2 per cent. of sodium ricinoleate. This article was responded to by Larson²⁴ who pointed out that Kozlowski had prepared his soap by purifying the ricinoleic acid through the barium salts.

The barium was apparently the cause of the ulceration and toxic effect. Larson²⁵ had discontinued this method of preparation of his soap and for several years has used isopropyl alcohol to remove all the non-saturated fatty acids. That the reaction of subcutaneous tissues to the solutions of sodium ricinoleate used by Larson must be slight was shown by Ekola.²⁶ Soap and diphtheria toxin-soap vaccines were found to be but slightly more irritating to subcutaneous tissues than trypan blue, which is considered the least toxic of the vital dyes. Diphtheria toxin alone produced more necrosis than the soap or soap-toxin mixture used. This was a histological study of injected rabbits. Larson²⁷ stated that he had rarely seen abscess formation after injection of sodium ricinoleate. He quoted Green who stated he had practically never seen an abscess after more than one hundred thousand injections into foxes, of a distemper vaccine containing sodium ricinoleate. Green, Ziegler, Green and Dewey,²⁸ in 1928, used ricinoleated virus for active immunization of several thousand foxes, with resultant lowering of the mortality rate.

Kozlowski²⁹ later reported the action of sodium ricinoleate upon several bacteria. He found that streptococci isolated from cases of erysipelas, measles and scarlet fever were killed by this soap in a dilution of 1:5000 in seven hours, or sooner at 35° C. while in control cultures, without soap, they survived for more than a week.

Their growth was inhibited by this soap in a dilution of 1:20,000. Pneumococci were readily dissolved by sodium ricinoleate in a dilution of 1:5000. He found that *Bacillus paratyphosis*, *Bacillus dysenteriae*, *Bacillus coli-communis* and *Streptococcus faecalis* were quite resistant to the inhibitory and bactericidal action of sodium ricinoleate. Larson⁸ had noted that botulinis toxin was more resistant to sodium ricinoleate than tetanus toxin or diphtheria toxin. He assumed that this offered a possible explanation to the fact that neither diphtheria toxin nor tetanus toxin is absorbed in toxic form from the intestinal tract, while botulinis toxin is readily absorbed by the digestive organs. The contents of the intestinal tract have a low surface tension because of bile and soaps present which probably destroy tetanus, and diphtheria toxins but not botulinis toxin. This also recalls the lytic action of bile on the pneumococcus. Kozlowski²⁹ suggested that sodium ricinoleate might be used instead of bile in dissolving pneumococci in diagnostic routine work. However Spencer³⁰ in an extensive study of the visible effect of sodium ricinoleate on suspensions of eighty-three species of bacteria tested his cultures of pneumococci several times and found that they were only slightly cleared. He found that *Bacterium tularensense* suspensions completely cleared with a soap dilution of 1:800.

So far as his tests had been carried out the reaction of *Bacterium tularensense* was unique and he suggested this effect as an additional criterion for identity of this organism.

This covers the work done with sodium ricinoleate prior to 1929, except that of Spencer and Ekola, which was done in 1929 and 1930.

While a student at the University of Minnesota in 1927, where Larson was working, I studied the rate of absorption of various substances from the peritoneal cavity of dogs. It occurred to me that the addition of sodium ricinoleate might aid the animals to survive the large amount of toxic exudate found in the peritoneal cavity after ligation, trauma or infection of the intes-

tines. Many substances, including sodium chloride solution, glucose, ether, pastes, and Dakin's solution, have been used in the peritoneal cavity to combat peritonitis. Most of these substances have been used for their bactericidal effect, some for their inhibitory effect on bacterial growth, others because they attract polymorphonuclear leucocytosis and still others were used simply empirically. No substance has been available that combined bactericidal, inhibitory and *detoxifying* powers until the introduction of sodium ricinoleate. I first suggested its use in peritonitis in 1928³¹ and Larson very kindly furnished me with samples prepared in his laboratory.

The first animal experiments were done early in 1929. Frequent changes of station have interrupted my animal experimentation and I have not had access to a large number of clinical cases of peritonitis, so that I am deferring until later the detailed report of my own experience, offering at this time the general results and a review of the literature covering its clinical use with the hope of stimulating further study of the efficacy of sodium ricinoleate in the prevention and treatment of acute peritonitis.

Sodium ricinoleate has been used clinically by many workers. Early in 1925 Hartzell³² recommended use of a paste containing sodium ricinoleate in the local treatment of tooth sockets. Since that time much has been written in dental journals on this subject.

Dorst and Morris³³ studied a large series of patients suffering for years with "irritable colon" some of whom had frequently been diagnosed chronic appendicitis, peptic ulcer, chronic cholecystitis, spastic colitis and mucous colitis. After many years of effort to isolate some unusual organism that might account for the condition, they investigated the normal flora of the intestinal tract. Twenty-six of thirty patients tested showed marked sensitivity of the skin to one or several of the "normal strains." The authors then attempted to desensitize these patients by giving small doses of autogenous vaccine.

The results were gratifying but the treatment required several months. Similar cases had responded well to repeated doses of castor oil, an effect attributed to the change of castor oil to ricinoleates in the intestinal tract. They therefore gave five-grain doses of sodium ricinoleate suspended in olive oil in capsules with better results than were obtained with the castor oil. They then prepared a ricinoleated vaccine from the "normal strains" of the intestinal flora and found that it was tolerated without local or focal reaction in doses five times those of the untreated vaccine. The combined treatment of sodium ricinoleate capsules by mouth and injections of ricinoleated vaccine gave very good results.

Kline³⁴ reported fifteen cases of tuberculous enteritis which were greatly benefited by oral administration of sodium ricinoleate in capsules.

Lutterloh and Stroud³⁵ were the first to introduce sodium ricinoleate solution into the peritoneal cavity clinically. They used 2 per cent. sodium ricinoleate in 1 per cent. sodium chloride, pouring it into the belly cavity at operation where ruptured appendices were encountered. They did not report the amount they used. They stated that convalescence was much less stormy and that patients were free from discomfort after operation, and that the mortality rate was very low.

They report the use of sodium ricinoleate solution in osteomyelitis and the local application in the form of saturated dressings in cases as treatment for extensive burns.

My experiments to date seem to warrant the following comments. There is a great variation in the solutions of sodium ricinoleate now available.

Samples obtained in 1928 from Larson were found to be non-toxic when 10 cubic centimetres of 2 per cent. solution was injected into the peritoneal cavity of guinea-pigs. Solutions were made up fresh each time that experiments were carried out. However, after the sample of sodium ricinoleate was several months old, 10 cubic centimetres of 2 per cent. solutions regularly killed guinea-pigs in a few hours, even though the precautions were followed to make the solutions with distilled water, and to keep them in hard glass containers to avoid chemical change. Solutions which were cloudy after mixing were found to be toxic. This probably resulted from changes in the samples. Samples must be prepared by a method which assures freedom from non-saturated acids or barium in the final product. Even though small amounts of sodium ricinoleate solution are tolerated well in the peritoneal cavity, the total amount injected is limited both by irritant and toxic effects. Two rabbits were injected with 15 cubic centimetres of 2 per cent. solution. One died in thirty-six hours and the other died in seventy-two hours. In the latter were found dense intestinal adhesions and a small amount of exudate, and in both cases the peritoneal cavity showed evidence of pronounced irritation. This irritation should not prevent utilization of sodium ricinoleate in weaker concentration since a mild irritation is considered beneficial in peritonitis, as a stimulant to attract polymorphonuclear leucocytes to the site of infection. Two rabbits were then injected with the same total dose, .3 gram of sodium ricinoleate, but in a dilute solution of 0.5 per cent. Both of these rabbits died within three hours. Two rabbits were injected with the same amount of 0.5 per cent. solution made up in normal saline, and died within two hours. This seems to warrant the assumption that the sodium ricinoleate was absorbed more rapidly in the dilute aqueous solution, since more peritoneal area was affected by the solution of greater quantity. Normal saline being a medium more nearly simulating body fluids probably facilitated the more rapid absorption of the toxic substance. However, small amounts of sodium ricinoleate have been injected into the peritoneal cavity hundreds of times by Larson and others and I have found small amounts to have no toxic effect. More detailed animal experiments will be reported later on the lethal dose. Many animals have been protected by the addition of sodium ricinoleate to cultures injected intraperitoneally. A broth culture of a streptococcus obtained from a fatal case of septicæmia was injected intraperitoneally into guinea-pigs, and death followed within forty-eight hours.

Equal amounts of the culture to which 1 cubic centimetre of 2 per cent. sodium ricinoleate was added in the syringe at the time of injection, proved less rapidly fatal, the animals living for several days. Preliminary work done on intraperitoneal injection of killed cultures of organisms, to which sodium ricinoleate was added, indicate that active immunization against the usual organisms soiling the peritoneal cavity might prove valuable in increasing the immunity to these organisms. This idea is based on the work of Herrman³⁶ and of Rankin and Bargaen^{37, 38} who have reduced operative mor-

tality by peritoneal vaccination prior to surgical procedures on the large bowel. It is believed that greater doses of vaccine may be given intraperitoneally if sodium ricinoleate has been added. The work of Dorst and Morris³³ indicates that oral administration of sodium ricinoleate prior to operation and in the presence of acute peritonitis may prove valuable in lowering operative mortality. As stated by Larson and others, streptococci and pneumococci are killed by sodium ricinoleate and large amounts of their toxins are rendered non-toxic. I have found sodium ricinoleate effective in killing a suspension of gonococci in 1:1,000,000 solution after three minutes contact in vitro. Clinically 0.5 per cent. sodium ricinoleate solution has given encouraging results in the treatment of gonorrheal urethritis, but the series is too small to warrant its recommendation without proven value in a large series of cases.

The unusual susceptibility of streptococci and pneumococci and their toxins to sodium ricinoleate suggests that sodium ricinoleate may be of value in the treatment of empyæma.

The work of Morris and Dorst³³ has shown that sodium ricinoleate is effective on the bacteria of the normal flora of the intestinal tract. The work of Larson and many others has shown that sodium ricinoleate is bactericidal to streptococci, pneumococci, *Bacillus diphtheria*, and that the toxins of these organisms are rendered non-toxic when sodium ricinoleate has been added in proper amounts. This indicates that we have a valuable substance in combating the organisms and toxins which account for the majority of fatal infections of the peritoneal cavity. Sodium ricinoleate would seem especially valuable in pneumococcic and gonococcic peritonitis. The use of an aqueous solution of sodium ricinoleate may not be the best. Lutterloh and Stroud³⁵ used 1 per cent. saline as a medium. My experience with normal saline as a medium tends to show that there is more danger than with aqueous solutions. Some work has been done on buffers, which is not ready for publication. The discovery of Johnson³⁹ that amniotic fluid spilled into the peritoneal cavity at the time of Cæserian section has resulted in a less stormy convalescence suggests that this may be a valuable diluent for sodium ricinoleate.

The action of sodium ricinoleate on toxins is believed by Larson to be an adsorptive phenomenon. Physical factors are involved which have not been explained. It would seem advisable therefore to seek a medium which is the most nearly a normal body fluid. Much experimental work must be done before sodium ricinoleate can be proven acceptable in the treatment of peritonitis. Clinical use will not be warranted until large series of animal experiments indicate the dosage, strength of solutions, diluents, time of administration, and limitations of this form of treatment. A series of animal experiments are now in progress which will be reported at a later date. Chemically pure sodium ricinoleate has been recently put on the market commercially.⁴⁰

BIBLIOGRAPHY

- ¹ Walker, J. E.: The Germicidal Properties of Chemically Pure Soaps. J. Infect. Dis., vol. xxxvi, pp. 557-566, December, 1924.

- ² Nicholas, H. J.: Bacteriologic Data on the Epidemiology of Respiratory Diseases in the Army. *J. Lab. and Clin. Med.*, vol. v, pp. 502-511, May, 1920.
- ³ Reasoner, M. A.: The Effect of Soap on *Treponema Pallidum*. *J. Am. Med. Assn.*, vol. lxviii, pp. 973-974, March 31, 1917.
- ⁴ Walker, J. E.: The Germicidal Properties of Soap. *J. Infect. Dis.*, vol. xxxvii, pp. 181-192, August, 1925.
- ⁵ Tilley, F. W., and Schaffer, J. M.: Germicidal Efficiency of Coconut Oil and Linseed Oil Soaps and of Their Mixtures with Cresol. *J. Infect. Dis.*, vol. xxxvii, pp. 359-367, October, 1925.
- ⁶ Page, I. H., and Allen, E. U.: The Action of Soap on the Animal Organism. *Proc. Staff Meetings Mayo Clinic*, vol. v, pp. 352-354, 1930; *Arch. f. exper. Patl. u. Pharmacol.*, vol. clii, pp. 1-26, 1930.
- ⁷ Larson, W. P., and Montank, I. A.: The Effect of Wetting on the Pathogenicity and Viability of the Tubercle Bacillus. *Proc. Soc. Exp. Biol. and Med.*, vol. xx, pp. 229-232, January, 1923.
- Wolf, C. G. L.: The Influence of the Surface Tension on Growth of Bacteria. *Biochem. J.*, vol. xvii, pp. 813-826, 1923.
- Larson, W. P., and Halvorson, H. O.: The Effect of Concentration upon the Neutralization of Toxin by Sodium Ricinoleate. *Proc. Soc. Exp. Biol. and Med.*, vol. xxii, p. 550, May, 1925.
- Larson, W. P., Halvorson, H. O., Evans, R. D., and Green, R. G.: The Effect of Surface Tension Depressants upon Bacterial Toxins. *Colloid Sympos. Monograph*, vol. iii, pp. 152-157, 1925.
- ⁸ Larson, W. P., and Nelson, E.: The Effect of the Surface Tension on the Medium upon Bacterial Growth. *Proc. Soc. Exp. Biol. and Med.*, vol. xxi, pp. 278-279, February, 1924.
- ⁹ Larson, W. P., Evans, R. D., and Nelson: The Effect of Sodium Ricinoleate upon Bacterial Toxins and the Value of Soap-toxin Mixtures as Antigens. *Proc. Soc. Exp. Biol. and Med.*, vol. xxii, p. 194, December, 1924.
- ¹⁰ Larson, W. P., and Nelson: The Antigenic Properties of Pneumococci and Streptococci Treated with Sodium Ricinoleate. *Proc. Soc. Exp. Biol. and Med.*, vol. xxii, p. 357, March, 1925.
- Day, A. A., and Gibbs, W. M.: The Effect of Sodium Ricinoleate on *L. Acidophilus* and *L. Bulgaricus*. *J. Infect. Dis.*, vol. xliii, pp. 97-107, August, 1928.
- ¹¹ Larson, W. P., and Colby, W.: Immunization Against Scarlet Fever Using Sodium Ricinoleate as a Detoxifying Agent. *Proc. Soc. Exp. Biol. and Med.*, vol. xxii, p. 549, May, 1925.
- Colby, W.: The Dick Test and Active Immunization Against Scarlet Fever with Detoxified Toxin. *Minn. Med.*, vol. viii, pp. 568-571, September, 1925.
- McBroom, D. E.: Scarlet Fever and Diphtheria Prevention Reactions in 2,000 Immunizations. *Minn. Med.*, vol. x, pp. 596-598, October, 1927.
- ¹² Larson, W. P., Hancock, and Eder, H.: Antidiphtheritic Immunization Using Sodium Ricinoleate as a Detoxifying Agent. *Proc. Soc. Exp. Biol. and Med.*, vol. xxii, p. 552, May, 1925.
- ¹³ Larson, W. P., and Eder, H.: Immunization Against Diphtheria. *J. Am. Med. Assn.*, vol. lxxxviii, pp. 998-999, April 3, 1926.
- ¹⁴ Larson, W. P., Huenekens, E. J., and Colby, W.: Immunization Against Scarlet Fever. *J. Am. Med. Assn.*, vol. lxxxviii, pp. 1000-1001, April 3, 1926.
- ¹⁵ Carmichael, E. B.: Detoxification of and the Immunity Production of Ricin by Sodium Ricinoleate. *Proc. Soc. Exp. Biol. and Med.*, vol. xxiv, pp. 5-7, October, 1926.
- ¹⁶ Carmichael, E. B.: Detoxification of Rattlesnake Venom by Sodium Ricinoleate. *J. Pharm. and Exp. Therap.*, vol. xxxi, pp. 445-454, October, 1927.

SODIUM RICINOLEATE IN PERITONITIS

- ¹⁷ McKinley, J. C., and Larson, W. P.: Sodium Ricinoleate and Active Immunity Against Experimental Monkey Poliomyelitis. *Proc. Soc. Exp. Biol. and Med.*, vol. xxiv, pp. 297-301, January, 1927.
- ¹⁸ Netter, A., Andre, E., Cesari, E., and Cotoni, L.: Action du Ricinoleate de Sodium sur les Bacteries et les Toxines. *Compt. red. de la Sec. Biol.*, vol. xcvi, pp. 184-186, January 22, 1927.
- ¹⁹ Netter, A., Coshni, and Cotoni, L.: Note: *Presse Med.*, vol. xxxv, p. 135, 1927.
- ²⁰ Cotoni, L., and Cesari, E.: Streptococoques et Immunization Antistreptococcique. *Ann. l. Inst. Pasteur.*, vol. xli, pp. 1270-1291, 1927.
- ²¹ Renaud, M.: Pouvoir Neutralisant des Savons sur le Venim de Cobra (Crytotoxine Venimeuse). *Compt. Red. Sr. Biol.*, vol. xcix, pp. 496-499, July 13, 1928.
- ²² Halvorson, H. O.: The Preparation of Pure Sodium Ricinoleate. *Proc. Soc. Exp. Biol. and Med.*, vol. xxii, p. 553, May, 1925.
- ²³ Kozłowski, A.: The Effect of Ricinoleated Vaccine of the Hæmolytic Streptococci (Scarlet Fever) on Animals. *J. Immunol.*, vol. xv, pp. 115-121, March, 1928.
- ²⁴ Larson, W. P.: Ricinoleated Streptococcic Vaccines. *J. Immunol.*, vol. xv, p. 299, July, 1928.
Kozłowski, A.: Ricinoleated Vaccines. *J. Immunol.*, vol. xvi, pp. 357-358, April, 1929.
- ²⁵ Larson, W. P.: Personal Communication. December, 1931.
- ²⁶ Ekola, M. W.: Reaction of Subcutaneous Tissues to Sodium Ricinoleate and Other Foreign Substances. *Proc. Soc. Exp. Biol. and Med.*, vol. xxvi, pp. 854-856, June, 1929.
- ²⁷ Larson, W. P.: Personal Communication, August, 1930.
- ²⁸ Green, R. G., Ziegler, N. R., Green, B. B., and Dewey, E. T.: Epizootic Fox Encephalitis. *Am. J. Hygiene*, vol. xii, pp. 109-129, July, 1930.
- ²⁹ Kozłowski, A.: A Comparative Study of the Action of Sodium Ricinoleate Upon Bacteria. *J. Bact.*, vol. xvi, pp. 203-209, September, 1928.
- ³⁰ Spencer, R. R.: The Visible Effect of Castor-oil Soap on Certain Organisms. *Public Health Reports*, vol. xlv, pp. 1354-1360, June 13, 1930.
- ³¹ Seeley, S. F.: Personal Communication to W. P. Larson, 1928.
- ³² Hartzell, T. B., and Larson, W. P.: Neutralization of Bacterial Toxin. *J. Am. Dent. Assn.*, vol. xii, pp. 271-272, 1925.
Hartzell, T. B.: Etiology of Pyorrhea Alveolaris with a Simplified Treatment. *J. Am. Dent. Assn.*, vol. xii, p. 1452, 1925.
Hartzell, T. B.: Factors in the Control and Care of Pyorrhea. *J. Am. Dent. Assn.*, vol. xiv, pp. 2056-2063, 1927.
Hartzell, T. B.: The Explanation of the Failure of the Dental Profession to Prevent Dental Disease. *Dent. Cosmos.*, vol. lxix, p. 1095, 1927.
Hartzell, T. B.: Bacteria. *J. Am. Dent. Assn.*, vol. xv, p. 516, 1928.
Delling, F. C.: Bacteriology as Applied to Clinical Dentistry. *Am. Dent. Surg.*, vol. xlvi, p. 699, 1926.
Booth, W. W.: Report on the Use of Soricin and of Ammoniacal Silver Nitrate and Formalin. *Dent. Items of Interest.*, vol. 1, pp. 849-850, 1928.
Aiguier, J. E.: Use of Drugs in Dentistry; Administration, Application and Limitation. *J. Am. Dent. Assn.*, vol. xvii, pp. 1426-1441, 1930.
Hopkins, A. S.: Detoxification in Treatment of Acute and Chronic Peridontal Diseases by Sodium Ricinoleate. *Dent. Cosmos.*, vol. lxxii, pp. 830-841, 1930.
Jones, H. E.: The Dentifrice Problem. *Clin. Med. and Surg.*, vol. xxxvi, pp. 42-44, 1929.
Jones, H. E.: Sodium Ricinoleate and Some Results Obtained with It in Dental Therapeutics. *Dent. Cosmos.*, vol. lxix, p. 247, 1927.
- ³³ Dorst, S. E., and Morris, R. S.: Bacterial Hypersensitivity of the Intestinal Tract—Its Treatment with Autogenous Vaccine and Sodium Ricinoleate. *Am. J. Med. Sc.*, vol. clxxx, pp. 650-656, November, 1930.

- Morris, R. S., and Dorst, S. E.: Sodium Ricinoleate in Allergic Diseases of the Intestinal Tract. *Am. J. Med. Sc.*, vol. clxxviii, pp. 631-632, November, 1929.
- Morris, R. S., and Dorst, S. E.: The Use of Sodium Ricinoleate in Bacterial Hypersensitiveness of the Intestinal Tract. *Annals Int. Med.*, vol. iv, pp. 396-397, October, 1930.
- ³⁴ Kline, L. B.: Sodium Ricinoleate in the Treatment of Intestinal Tuberculosis. *U. S. Vet. Bur. Med. Bull.*, vol. vi, pp. 295-297, April, 1930.
- ³⁵ Lutterloh, P. W., and Stroud, H. A.: Detoxification Treatment in Burns, Suppurating Wounds and Surgical Abdominal Cases. *Internat. J. Med. and Surg.*, vol. xlv, pp. 16-18, January, 1931.
- Lutterloh, P. W.: The Control of Infection. *Internat. J. Med. and Surg.*, vol. xlv, pp. 120-126, March, 1931.
- ³⁶ Herrmann, S. F.: Experimental Peritonitis and Peritoneal Immunity. *Arch. Surg.*, vol. xviii, pp. 2202-2215, May, 1929.
- ³⁷ Rankin, F. W., and Bargaen, J. A.: Intraperitoneal Vaccination by Mixed Vaccine of Colon Bacilli and Streptococci. *Arch. Surg.*, vol. xix, p. 906, November, 1929.
- ³⁸ Rankin, F. W., and Bargaen, J. A.: Vaccination Against Peritonitis in Surgery of the Colon. *Arch. Surg.*, vol. xxii, pp. 98-105, January, 1931.
- ³⁹ Johnson, H. L.: Observations on the Prevention and Treatment of Post-operative Peritonitis and Abdominal Adhesions. *Surg. Gynec., and Obst.*, vol. xlv, pp. 612-619, November, 1927.
- ⁴⁰ Wm. S. Merrell Co.: Cincinnati, Ohio.

INTERNAL HERNIA FOLLOWING POSTERIOR GASTROENTEROSTOMY*

BY EDWIN PORTER BUCHANAN M.D.

OF PITTSBURGH, PA.

SURGEON TO MERCY HOSPITAL

A HERNIA is variously defined as: (1) A rupture; (2) the protrusion of an organ or part of an organ or other structure through the wall of the cavity normally containing it; (3) the protrusion of a loop or knuckle of an organ or tissue through an abnormal opening; (4) the protrusion of peritoneum liable to contain, containing at times, or permanently containing any viscus or part of a viscus from the abdominal cavity.

No one of these definitions satisfies all types of hernia, as is quite evident when we consider that condition in which loops of small intestine pass through the Foramen of Winslow into the lesser peritoneal cavity. Yet I think we will all agree in calling such a condition a hernia. It is the general conception that a hernia must possess a sac lined by peritoneum and if this is the true definition, the condition which I am about to describe cannot be classed as a hernia, but as an incarceration or strangulation, depending on the circulation of the bowel.

I shall proceed first to the description of my case and then briefly review the other cases found in the literature.

L. S., male, aged thirty-two years. Steelworker, was admitted to the Mercy Hospital on the night of March 3, 1929. He gave a history of indigestion dating back four years. Twenty-four hours previous to admission he had epigastric pains lasting four hours. Twelve hours before admission the pains returned with increased violence and he began to vomit. He was seen by a physician who administered morphine and prescribed ice to the abdomen without relief. Physical examination on admission revealed a flat abdomen, generalized rigidity—boardlike in the epigastrium—and marked tenderness. Pulse, 96; temperature, 98.6°; blood-pressure, 138/90.

Under diagnosis of perforated gastric ulcer the abdomen was opened. On the anterior wall of the duodenum just outside the pylorus was an ulcer the size of a five-cent piece with a perforation the size of a slate pencil. Ten ounces of bile and gastric secretion were obtained by passing an aspirator to all parts of the abdomen. The ulcer was excised by cautery and closed with silk. The duodenum was so narrowed that a posterior short loop retrocolic gastroenterostomy was performed. The opening in the transverse mesocolon was anchored about the anastomosis and the abdomen closed without drainage. Six hours after the operation he vomited thirty-five ounces of bile-stained fluid and smaller amounts during the first three days. Nine days after operation, during an attack of coughing, the wound opened, forcing out a piece of omentum. Secondary suture of the wound was required. His general condition, however, remained good till early in the morning of the eighteenth day. There had been no recurrence of the vomiting since the third day; bowels were moving twice a day naturally and he was taking a liberal diet. Suddenly he was seized with violent

* Read before the Pittsburgh Academy of Medicine, March 22, 1932.

abdominal pain, chiefly in the left hypochondrium. The pains were intermittent and he vomited large quantities of bile-stained fluid. The upper abdomen was somewhat rigid, chiefly on the left side. Tenderness and fullness in this region were accentuated during the pains. A diagnosis of acute intestinal obstruction was made and under ether anæsthesia, the abdomen was again opened about ten hours after the onset of pain through a left upper rectus incision.

A loop of slightly distended, congested jejunum, about three feet in length, was found in the left hypochondrium. It had passed from right to left between the afferent loop of jejunum and the lower leaf of the transverse mesocolon, thus forming an



FIG. 1.—Internal hernia of jejunum.

internal hernia (Fig. 1). This was easily reduced. The weight of this loop of bowel had produced a kink in the jejunum just opposite the anastomosis with a resulting vicious circle. To prevent a recurrence of the hernia, the proximal loop of jejunum was anchored to the lower leaf of the transverse mesocolon with one suture. An entero-anastomosis between the proximal and distal loops was performed to prevent any recurrence of the vicious circle. Convalescence was uneventful. He was discharged from the hospital six weeks after admission. He returned to work nine days after leaving the hospital and during the first five and one-half months lost only one day.

On November 3, 1929 (eight months after his first admission), he was re-admitted

to the Mercy Hospital with a history of pains dating back two months. During the last month they had been especially severe, occurring daily just after meals, frequently accompanied by vomiting and not relieved by diet or medication. A diagnosis of marginal ulcer was made although confirmation could not be obtained by X-ray.

November 13, ten days after admission, the abdomen was opened for the third time. There was an ulcer of the jejunum less than an inch distal to the gastro-jejunostomy. It had perforated the bowel, forming a crater the size of a dime on the under-surface of the transverse colon. The original duodenal ulcer showed only a very faint scar. The gastroenterostomy was torn down and the openings in the stomach and bowel closed, thus reestablishing the normal tract. The wound healed by primary union. Convalescence was uneventful and the patient was discharged from the hospital sixteen days after operation. Twelve days later he requested that he be permitted to do light work. A few weeks ago I saw this patient and he again has mild symptoms of duodenal ulcer.

For many years the possibility of a herniation through the opening of the transverse mesocolon into the lesser peritoneal cavity has been recognized. To prevent such a complication following posterior gastroenterostomy it has become a universal custom to anchor the margins of the opening in the transverse mesocolon about the anastomosis.

Herniation of small intestine between the proximal loop of jejunum and transverse mesocolon has occurred so rarely that preventive steps are seldom taken unless the surgeon has had such a case. All that is necessary is the obliteration of the opening by one or two sutures anchoring the proximal jejunal loop to the under-surface of the transverse mesocolon.

In 1915, Moschcowitz and Wilensky collected two cases complicating anterior long-loop gastroenterostomy (Peterson, Mayo) and six cases complicating short-loop retrocolic anastomosis (Steudel, Peterson, Gray, Gordon, Barker, Moschcowitz and Wilensky). To these, Fowler has added three cases complicating short-loop (Ashhurst, Bryan, Fowler). The author has discovered two other case reports, one by Winkelbauer complicating short-loop retrocolic anastomosis and the other by Steden complicating long-loop antecolic gastroenterostomy.

The complete list comprising eleven cases complicating short-loop and three cases complicating long-loop operations is given in the opposite table, together with the essential facts where available.

Although many theories have been advanced as to the etiology of this unusual complication, most of them are fantastic and far-fetched. From the study of the cases reported a number of interesting points are discovered. W. J. Mayo stated thirty years ago that the danger is much greater with the anterior long-loop operation than with the posterior short-loop anastomosis. That statistics do not bear out this statement is probably due to the fact that anterior gastroenterostomy is now but rarely performed. Of the twelve cases where the direction of the passage of the loop is mentioned, in all but one was it from right to left. Where the retrocolic anastomosis was employed, the complication occurred in all but one case within the first three weeks, whereas in two of the three long-loop antecolic anastomoses, the incarceration did not occur till one year and nine months respectively after the original operation. Almost always within the first few days after the retrocolic anastomosis there is vomiting of massive

TABLE.—HERNIATION OF SMALL INTESTINE

Reference	Internal Primary Condition	Primary Operation	Diagnosis of Hernia Made by	Elapsed Time After Anastomosis	Direction of Passage of Loop	Length of Incarcerated Loop	Result
Steudel	Cancer	Resection and posterior gastroenterostomy with Murphy button	Autopsy	17 days	Right to left	Short loop	Death
Peterson	Cancer	Resection and anterior anastomosis with Murphy button	Autopsy	6 days	Right to left	Most of small bowel	Death
Peterson	Cancer	Posterior gastroenterostomy	Autopsy	10 days	Right to left	All small intestine	Death
W. J. Mayo	Ulcer lesser curvature	Anterior gastroenterostomy with Murphy button	Operation	1 year later	Right to left	More than half small intestine	—
Gray	Ulcer	Posterior short loop gastroenterostomy	Operation	6 days	Left to right	All small intestine	Recovery
Gordon	—	Posterior gastroenterostomy	Operation	—	Right to left	—	Recovery
Barker	—	Posterior gastroenterostomy	Operation	2 years	—	All small intestine	Recovery
Moschowitz	Ulcer	Posterior gastroenterostomy	Operation	14 days	Right to left	Most of small intestine	Death
and Wilensky							
Bryan	Perforated duodenal ulcer	Posterior gastroenterostomy	Operation	12 days	Right to left	All small intestine	Recovery
			Second operation for recurrence	6 days	Right to left	? Small intestine	
Fowler	Ulcer lesser curvature	Posterior gastroenterostomy	Operation	12 days	Right to left	1 foot	Recovery
Steden	Perforated gastric ulcer	Anterior gastroenterostomy	Operation	9 months	Right to left	Most all small intestine	Death
Winkelbauer	Duodenal ulcer	Resection and retrocolic end to side	Operation	9 days	Right to left	Most all small intestine	Death
Buchanan	Perforated duodenal ulcer	Posterior gastroenterostomy	Operation	18 days	Right to left	About three feet	Recovery
H. C. Deaver**	Carcinoma	Anterior long loop gastroenterostomy	Autopsy	—	—	—	Death

** By personal communication with Dr. Astley P. C. Ashurst.

quantities of bile-stained fluid, indicating a vicious circle with dilatation from improper drainage. In eight of the cases almost the entire small bowel was incarcerated. In the other four cases, where any mention is made, the length of the loop varied from one foot to half the small intestine. Frequently the condition is ushered in with collapse not associated with pain. The degree of shock probably depends on the length of the incarcerated loop together with the amount of interference to its blood supply. A number of the patients, however, experienced pain and all the symptoms of acute obstruction.

While vomiting and coughing probably play some part in the production of internal hernia, they occur so commonly and the complication under discussion so rarely, that there are undoubtedly other factors of which we have no absolute knowledge.

Bryan's case is the only one where there was a recurrence of the condition. The first hernia appeared twelve days after the gastroenterostomy and the second six days later. At the second operation to prevent recurrence he not only closed the opening as is generally advised, but performed entero-anastomosis and sutured the descending loop to the parietal peritoneum.

In conclusion, I may state that internal hernia or incarceration of small intestine complicating short-loop retrocolic anastomosis is a rare condition. The factors producing it have never been satisfactorily explained. It is generally preceded by the vomiting of large quantities of bile. It usually occurs from one to three weeks following operation. There may be collapse without pain or pain and all the symptoms of intestinal obstruction. The only treatment is early operation. The preventive treatment is the obliteration of the fissure by one or two sutures between the proximal loop and the lower leaf of the transverse mesocolon.

BIBLIOGRAPHY

- The American Illustrated Medical Dictionary, seventh edit.
 Stedman's Medical Dictionary, fifth edit.
 DaCosta: Modern Surgery, eighth edit., p. 1275.
 Moschcowitz, and Wilensky: Surg., Gynec., and Obst., vol. xxi, p. 390, July, 1915.
 Mayo, W. J., ANNALS OF SURGERY, vol. xxxvi, 1902.
 Fowler: ANNALS OF SURGERY, vol. xciv, p. 144, July, 1931.
 Deaver, and Ashhurst: Surgery of Upper Abdomen, second edit., p. 396.
 Bryan: Surg. Gynec., and Obstet., vol. xxx, p. 82, January, 1920.
 Winkelbauer: Zentralblatt für Chirurgie, vol. liii, p. 2642, October 16, 1926.
 Steden: Betr. z. klin. Chir., vol. cxxxi, p. 486, 1924.

POSTERIOR PITUITARY EXTRACT IN THE PREVENTION OF POST-OPERATIVE INTESTINAL DISTENSION

A PRELIMINARY REPORT*

BY PHILIP C. POTTER, M.D.

AND

R. STERLING MUELLER, M.D.

OF NEW YORK, N. Y.

FROM THE DEPARTMENT OF SURGERY OF COLUMBIA UNIVERSITY, AND THE FIRST SURGICAL DIVISION
OF BELLEVUE HOSPITAL

POST-OPERATIVE paralytic ileus is one of the major complications of abdominal surgery. Preceding any true ileus there are varying grades of intestinal distension. This distension is primarily due to a loss of tone of the smooth muscle of the intestinal tract caused by changes in intra-abdominal pressure, handling of the viscera, changes in temperature, the anæsthetic, morphine, and the presence of infection within the peritoneal cavity. This atonia varies in degree and duration and is most often encountered in the presence of peritonitis. Much has been written concerning the treatment of post-operative distension and ileus once these complications have arisen, but there is little to be found in the literature concerning means for their prevention.

Some three years ago a study was undertaken on the wards of the First Surgical Division, Bellevue Hospital, the object of which was to work out, if possible, a method for the prevention of post-operative distension, hence paralytic ileus. It was felt that if the tone of the intestine could be maintained during the first few post-operative days—in other words, through the atonic period—the smooth muscle could then resume its normal function.

To arrive at some idea of the prevalence of post-operative distension, 100 consecutive cases of acute appendicitis were reviewed. In 40 per cent. of these cases there was sufficient distension during the first three post-operative days to require the use of enemas, irrigations, rectal tubes or stupes. There were two cases of paralytic ileus. Twenty-one of these patients had to be catheterized.

The employment of posterior pituitary extract has been recommended for many years in the treatment of distension and ileus. Its action on distended intestine is sometimes violent and of short duration and some surgeons have advised against its use, fearing that any undue activity of the intestine might spread an existing peritonitis or blow out an appendix stump.

In 1924, in a paper on "Suppurative Peritonitis," Dr. Joseph A. Blake recommended the use of pituitary extract as a preventive routine, one ampoule of surgical pituitrin to be given after operation and continued at intervals of four hours for six doses, or more if indicated.

* Read before the New York Surgical Society, December 9, 1931.

In 100 abdominal cases of various types, this routine was followed. It was found that, whereas the incidence of post-operative distension was materially lessened, there were certain cases in which distension continued to be a problem. These could be classified under two headings: first, those in which considerable gas was present in the intestine at the end of the operation and before the administration of the initial dose of pituitrin; and second, those in which distension appeared after the final dose of pituitrin had been given. It was evident that in certain cases pituitrin had been started too late and that in others its use had not been sufficiently prolonged. The latter conclusion applied particularly to the cases of suppurative peritonitis. In the cases in which pituitrin had been given in the absence of distension, notably following spinal anæsthesia, clinically there was no indication of increased peristalsis, the effect of the drug being merely to maintain normal tone. The patients complained of no discomfort such as might be attributed to any violent activity of the intestinal musculature.

In 1928, Dr. Oliver Kamm and his co-workers isolated the alpha and beta hormones of posterior pituitary. The beta hormone has the vasopressor activity of the old pituitrin. It lacks the oxytocic or uterine. As this preparation, introduced under the name "Pitressin," seemed more specific for our purposes, it was substituted for pituitrin in our next series.

In our previous work, we had found that the two types of case in which post-operative distension was most apt to appear as a complication were acute appendicitis with or without peritonitis, and diseases of the biliary tract. It was therefore determined to limit our further observations to these two groups. It was felt that in cases operated upon under spinal anæsthesia, with its accompanying intestinal constriction, the first dose of pituitary extract could safely be given directly following operation, whereas with general anæsthesia the initial dose must be administered before operation. In the latter case, aside from forestalling any distension which might occur during operation, we hoped to be enabled to observe at first hand the action of the drug on the intestinal tract and to determine whether there was increased peristalsis or merely a maintenance of or slight increase in the existing tone of the intestine, as had appeared to be the case clinically. From our earlier observations we felt that the major effect would be found to be on the musculature of the small intestine rather than on that of the stomach or large intestine.

The second series was composed of fifty cases operated upon for acute appendicitis and fifty cases operated upon for biliary disease. In six of the former there was an accompanying spreading peritonitis and in eleven there was a localized peritoneal abscess. The routine as regarded pituitary extract was as follows: in the cases operated upon under spinal anæsthesia, an initial dose of pitressin was given intramuscularly directly following operation, and continued every four hours for eight doses in the case of uncomplicated appendicitis, for twelve doses in the biliary cases, and for fifteen doses or more where acute appendicitis was complicated by peritonitis. In two cases

of spreading peritonitis, pitressin was administered every four hours for twenty-eight and thirty-six doses respectively. All cases were carefully observed and evidences of intestinal distension, inability to void, and post-operative shock were noted. In twelve cases operated upon under general anæsthesia (avertin plus gas-oxygen) observations on the action of the drug in the open abdomen were made.

The results in this series were as follows: In ninety out of the hundred cases there was no evident distension. Of the remaining ten cases, eight became moderately distended following the final dose of pitressin. In one of the biliary cases there was marked distension. This patient was extremely stout and there appeared to be no effect from the administration of the drug. In the remaining case, one of acute appendicitis with peritoneal abscess, the distension was the result of a mechanical obstruction and an ileostomy was necessary. Seven patients were catheterized. In six of these spinal anæsthesia had been employed. There was no instance of post-operative shock. In no case, save that in which there existed a mechanical obstruction, was there any outward evidence of increased peristalsis. The action of the drug, as in our previous series, appeared to be that of merely maintaining tone.

In the appendicitis series there were two deaths. The first was a case of spreading peritonitis who died on the eighth day with extreme jaundice, the result of multiple liver abscesses, proved at autopsy. The second was referred to above—a late case with localized peritonitis and mechanical obstruction. This patient was sixty-five years of age and the immediate cause of death was bilateral bronchopneumonia. Autopsy revealed a band constricting the terminal ileum adjacent to the wall of the abscess. In the biliary series there were three deaths. The first was a case of common-duct stone in which death was due to pneumonia. In the second a choledochoduodenostomy had been performed for carcinoma of the head of the pancreas with stenosis of the cystic duct. Death was due to peritonitis. The third case was one of chronic cholecystitis with stones in the gall-bladder. Death was thought to be the result of a mesenteric thrombosis, although this could not be proved as further operation was refused and an autopsy was not obtained.

In twelve cases of biliary disease operated upon under general anæsthesia, an opportunity was had of observing the action of pituitary extract. In eleven of these cases a gradual generalized shrinkage of the small intestine was noted, but not of the degree seen following spinal anæsthesia. This came on between ten and twenty minutes following the intramuscular administration of pitressin, was not peristaltic in type, and remained throughout the operation. It made, in all instances, for an extremely easy closure. In one case there was no visible contracture of the small intestine. In none of these twelve cases was any effect on the musculature of the stomach or large intestine noted.

CONCLUSIONS

The prophylactic use of posterior pituitary extract has proved an effective means of minimizing post-operative abdominal distension.

When administered before the onset of intestinal smooth muscle relaxation, the result is a quiet abdomen, there being no evidence of increased peristalsis.

In 200 cases in which pituitary extract has been used as routine, no untoward results have been noted.

BIBLIOGRAPHY

- Blake, J. A.: The Treatment of Suppurative Peritonitis. *ANNALS OF SURGERY*, May, 1924.
- Kamm, Oliver, Aldrich, T. B., Grote, I. W., Rowe, L. W., and Bugbee, E. P.: The Active Principles of the Posterior Lobe of the Pituitary Gland. *Jour. Am. Chem. Soc.*, vol. 1, p. 573, 1928.
- Editorial: Separation of the Active Principles of the Posterior Lobe of the Pituitary Gland. *Jour. Am. Med. Assn.*, vol. xc, p. 618, 1928.
- Bugbee, and Kamm: Recent Progress in the Investigation of the Posterior Lobe of the Pituitary Gland. *Endocrinology*, vol. xii, pp. 671-679, 1928.
- Clark, G. A.: The Selective Vaso-Constrictor Action of Pituitary Pressor Extract. *Jour. Physiol.*, vol. lxx, p. 53, 1930.
- Carlson, H. A.: Effect of Posterior Pituitary Lobe Extracts on the Intestine of Man and Animals. *Proc. Soc. Exp. Biol. and Med.*, vol. xxvii, pp. 777-779, 1930.
- McIntosh, C. A., and Owings, J. C.: The Effect of Solutions of Pituitary and Various Drugs on the Movements of the Small Intestine During Simple Mechanical Obstruction. *Arch. Surg.*, vol. xvii, p. 996, 1928.
- Gruber, C. M., and Robinson, P. I.: The Influence of Pituitary Extract, "Vasopressin" and "Oxytocin" Upon the Intact Intestine in Unanæsthetized Dogs. *Jour. Pharmacol. and Exp. Ther.*, vol. xxvi, p. 203, 1929.
- Gaddum, J. H.: Some Properties of the Separated Active Principles of the Pituitary (Posterior Lobe). *Jour. Physiol.*, vol. lxxv, p. 434, 1928.

X-RAY DIAGNOSIS OF ACUTE INTESTINAL OBSTRUCTION WITHOUT THE USE OF CONTRAST MEDIA

BY LEON GINZBURG, M.D.

OF NEW YORK, N. Y.

FROM THE SURGICAL SERVICES AND DEPARTMENTS OF RADIOLOGY OF MT. SINAI HOSPITAL
AND HARLEM HOSPITAL OF NEW YORK CITY

THE method of X-ray diagnosis of acute intestinal obstruction by studies of the gas distribution and fluid levels is by no means a new one. Its use, however, is apparently not as widespread as its importance would seem to warrant. Writers on the subject of intestinal obstruction have been almost unanimous in deploring the late diagnosis and tendency to procrastination which keeps the mortality in this condition at its present high figures. In our hands the plain röntgenogram has proven a valuable, if not infallible, aid to diagnosis, and has been the determining factor leading to immediate operative intervention in cases clinically doubtful. Thus we have at times been able to avoid that period of observation during which the chances of the patient's recovery diminishes with the increasing clarity of the diagnosis. On the other hand, in cases where the diagnosis of obstruction was seriously considered, but where the röntgenological signs necessary for the diagnosis of mechanical occlusion were absent, it has resulted in the avoidance of unnecessary exploration. Another important virtue of this method is, that by enabling us to differentiate between obstruction of the colon and of the small bowel it has made it possible for us to determine pre-operatively upon the type of procedure which would give relief with minimal shock and manipulation.

It should by this time be unnecessary to caution against the oral administration of barium in cases of suspected intestinal obstruction, but the author has seen three cases in the past year where an acute obstruction was precipitated following an opaque meal.

The most complete and accurate data for röntgenological study will be obtained if plates are taken in the following three positions:

(1) With the patient lying on his back and the plate behind him—this gives the best conception of the topographical relation of the coils of small bowel to each other and to the large bowel. (Fig. 3.) In stout people, however, and in patients in whom there is as yet little distension, the presence of abnormal gas accumulations may be missed.

(2) With the patient lying on his abdomen and the plate beneath him—this position gives the sharpest definition of intra-intestinal gas and bowel outline. Its disadvantage is that dilated loops of small bowel may be displaced into the flanks by the pressure against the central portion of the abdomen interfering in the differentiation between colon and small bowel. (Figs. 1-4.)

(3) With the patient in the erect posture—this will permit the demonstration of fluid levels in the bowel by causing the gaseous contents to rise on top of the liquid contents. (Figs. 2-6.) In patients too sick to sit up Ochsner's suggestion of taking

plates with the patient lying on his side with the plate against his abdomen has proven satisfactory.

The plates should be taken before the administration of enemata or irrigation of the colon for the following reasons: In the first place the gas which may be present in the colon may be expelled, and a wrong conception of the type of gas distribution obtained. In the second place if the plate is taken too soon after the irrigation, retained fluid and gas introduced by it may not be completely absorbed or expelled, and may give rise to small fluid levels in the colonic saccules.

The following communication is based on the study of fifty-nine cases of acute mechanical occlusion of the bowel diagnosed as such röntgenologically and proven to be such by operation. Of these, the obstruction was in the ileum in thirty-nine cases, and in the colon in twenty. In addition, there have been an almost equal number of cases where the subsequent clinical course, operation or autopsy confirmed the X-ray conclusion that mechanical ileus was absent. In some of these cases the distension was definitely known not to be due to mechanical ileus, but studies were made in order to determine what portions of the bowel were mainly concerned in giving rise to the abdominal distension.

Acute Mechanical Occlusion of the Small Intestine.—Under normal conditions in the *adult* gas cannot be röntgenologically demonstrated in the small bowel. In the colon, however, it is a matter of every-day observation to note varying quantities of gas usually sufficient in amount to outline its distinctive markings and course. In neither portion of the bowel can fluid levels be demonstrated. When acute mechanical occlusion from any cause occurs in the small bowel, the gut proximal to the site of obstruction very rapidly becomes distended with gas and fluid. Distally, the entire enteric tract including the colon becomes empty and collapsed. Röntgenologically, this pathological alteration is mirrored by the following findings:

- (1) Presence of dilated coils of small bowel (normally absent).
- (2) Absence of gas in the colon (normally present).
- (3) Presence of fluid levels in the small bowel.

In our experience, the earliest sign to appear is the development of fluid levels. It was present in two cases where no dilatation of the small bowel could be demonstrated in the flat plate.

Aside from the two cases just mentioned, all of the thirty-seven proven cases of acute small bowel obstruction had these diagnostic signs. In no case where these signs were absent was the subsequent course one of acute mechanical obstruction. On the other hand, and this is important, from the standpoint of operative intervention, these signs are *not* absolutely pathognomonic of *mechanical* obstruction. We have observed these signs a number of times in cases of peritonitis and in severe post-operative paralytic ileus. (This point will be discussed again later.) At this juncture we must also note the exception provided by two cases of strangulated partial enterocele in which small globules of gas could be visualized in the colon together with distended coils of small bowel and fluid levels. (Fig. 9.)



FIG. 1.



FIG. 2.

FIG. 1.—Obstruction of the small bowel of two days' standing. Plate taken with patient lying on abdomen; the characteristic serrated ribbed appearance of the small bowel is well shown. Small bowel has been displaced into the flanks.

FIG. 2.—Fluid levels in an early obstruction of the small bowel.

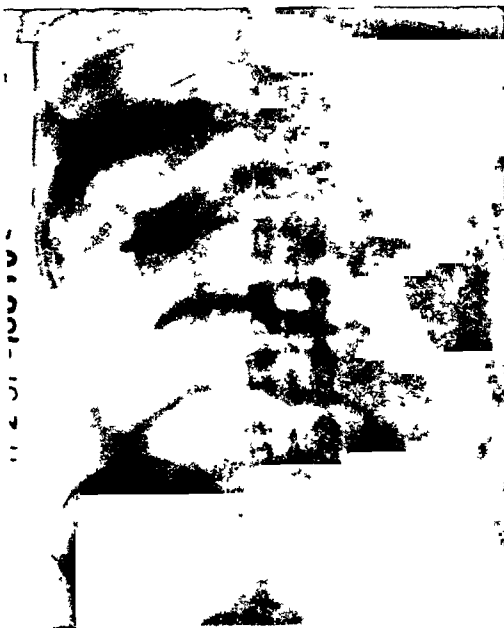


FIG. 3.



FIG. 4.

FIG. 3.—Classical example of small bowel obstruction, parallel loops of small bowel arranged in a ladder pattern. Obstruction twenty-four hours' duration due to band from previous appendix operation. Plate taken with patient on back.

FIG. 4.—Obstruction of the small intestine near the ileo caecal angle. Same patient as above. Plate taken with patient on abdomen. Gut displaced into flanks.

In order to facilitate clarity of reproduction positive plates are used instead of negative reproductions.

The value of the röntgenogram in helping to establish diagnosis is to a large extent predicated upon the ability to distinguish gas-distended small bowel from colon. The following points have proven of service in distinguishing between the two.

(1) Gas in the small bowel is usually centrally located. The bowel lies horizontally, and may show the so-called pipe organ or ladder pattern, especially if the plate is taken with the patient lying on his back. (Fig. 3.) Frequently, however, the coils may be few and irregularly situated, or there may be only one dilated loop. (Fig. 7.)

Gas in the colon is usually situated peripherally, in the flank. (Figs. 10-13.) The cæcum should always be sought for and will frequently show gas when no other portion of the large bowel can be visualized. With a ptotic transverse colon, gas may, however, occupy the central field. On the other hand, if the plate be taken with the patient on his abdomen, coils of small bowel may be displaced into the lateral colonic fields. (Figs. 1 and 4.)

(2) The colon is characterized by its blunter, deeper indentations due to its haustration. (Fig. 10.) The small intestine has a feathered or ribbed appearance due to its valvulæ conniventes. Its edges have a serrated appearance. These serrations are much more closely placed than the haustrations of the colon. (Fig. 1.)

(3) Gas in the small bowel appears as a homogeneous area of rarefaction in a well-defined loop. In the normal colon discrete spheroid globules of gas are often visualized, perhaps due to entrapment in its saccules.

(4) The fluid levels in the small bowel are centrally placed and have a short vertical height due to its general horizontal course and its numerous turnings. (Figs. 4, 5 and 6.) The large bowel shows fluid levels in the flanks and in the descending and ascending colon which are practically vertical tubes suspended from the flexures; the vertical height of the gas column may reach 4 to 6 inches. (Fig. 11.)

The mode of employment of these röntgenograms in helping to arrive at a diagnosis may perhaps be best illustrated by discussing various types of intra-abdominal small bowel obstruction as they have been encountered clinically. Parenthetically it may be stated that the extent of intestinal distension as shown by the plate is no index to the severity of the underlying condition. We have encountered gangrenous gut with relatively little visualization of loops of small bowel, and on the other hand we have found enormous gas distension in patients with a kinking non-strangulating obstruction.

(1) *Obstructions due to adhesions or bands from an old laparotomy.*—Twenty-one cases. Some of these cases entered the hospital with the diagnosis all too clear. There was a considerable group of them, however, which posed a familiar and difficult problem. The patient is admitted with an abdominal scar, cramps, constipation, nausea, perhaps a little vomiting, and with practically no distension or constitutional symptoms. Naturally, one is loath to operate upon this type of case on the available clinical evidence, and it is in this group in which there is frequently the clinical tendency to "sit



FIG. 5.



FIG. 6.

FIG. 5.—Early case of acute obstruction of the small bowel. Fourteen-hour history. Fluid levels present. In this case no distended loops of small bowel could be visualized on the flat plate. Note absence of gas in lateral colonic fields.

FIG. 6.—Case of tuberculous stricture of the upper ileum with acute obstruction, showing fluid levels and dilated small intestinal loops. Clinically, case was considered one of colonic tumor.



FIG. 7.



FIG. 8.

FIG. 7.—Unusual distribution of dilated small intestinal loops in a case of obstruction two feet from the ileo-caecal junction.

FIG. 8.—Case of acute ileo-colic intussusception in an infant. Fluid levels and distended small bowel in a case of ileo-colic intussusception. Note absence of gas in lateral colonic fields.

tight" and await developments, that the X-ray has probably proven of greatest value.

Practically all post-operative acute obstructions due to bands or adhesions occur in the small bowel. Therefore, if dilated loops of small bowel can be visualized with an absence of gas in the colon, a diagnosis of mechanical occlusion can be made. If possible, one should not depend upon the presence of fluid levels alone, for we have seen fluid levels following an attack of renal colic in a patient who had previously been subjected to an appendectomy because of a similar attack. This patient, however, had large quantities of gas in the colon. On the other hand, we have had two cases where fluid levels were found, and in which neither large nor small bowel could be visualized on the flat plate. These patients both had mechanical obstruction.

If gas can be demonstrated in the colon one can be fairly sure that the symptoms are not a result of mechanical obstruction connected with the previous operation. This was borne out in ten cases with previous laparotomy, whose presenting symptoms suggestive of ileus were later shown to be due to such diverse conditions as neuro-syphilis, uræmia, coronary artery disease, poisoning by bootleg alcohol, renal colic, retroperitoneal hæmatoma, low-grade pancreatitis and the lighting up of inflammation in diseased fallopian tubes left behind in a conservative pelvic operation.

In this particular type of obstruction following previous laparotomy, we can say unequivocally that the X-ray frequently gave us more accurate information than the clinical signs. In a number of these cases expulsion of gas had been reported following enemata, and because of the absence of the text-book (or advanced) symptoms of ileus, there was some tendency to favor conservative therapy. In a number of these cases laparotomy, undertaken largely on the strength of the röntgenogram, disclosed definite evidence of mechanical occlusion which could not possibly have been relieved spontaneously. In other words, when the clinical appearances conflicted with the röntgenographical findings, operation proved the latter to be correct.

(2) *Obstruction due to kinking around a colostomy spur.*—Two cases. In one of these patients an abdomino-perineal resection had been performed for carcinoma of the rectum. When signs of obstruction occurred, they were considered by the family physician as due to a colonic obstruction from a recurrence higher up in the colon. X-ray ruled out the possibility of colonic obstruction and demonstrated a small bowel obstruction, which was successfully relieved by operation. In the other case, a colostomy which had been performed for a stenosing proctitis and sigmoiditis underwent considerable narrowing and retraction. The onset of the obstructive symptoms in this patient were at first also attributed to colonic obstruction. X-ray revealed no gas in the colon and dilated loops of small bowel, the findings being verified by operation.

(3) *Obstruction occurring in the immediate post-operative course.*—Four cases. The ileum is the usual site of obstruction in this type of case, and *a priori* it might be assumed that the röntgenogram would be of as much



FIG. 9



FIG. 10.

FIG. 9.—Strangulated partial enterocoele. Dilated loops of small bowel marked by X. Arrows point to gas in colon.

FIG. 10.—Obstruction due to carcinoma of the lower sigmoid. Entire large bowel distended with gas. Caecum enormously dilated, outlined by arrows. Typical haustration of colon.



FIG. 11.



FIG. 12.

FIG. 11.—Fluid levels in a case of acute obstruction of the lower descending colon by carcinoma. Note the height of the columns of gas on top of the fluid as well as the typical colonic markings.

FIG. 12.—Distension of left and right colon by gas in an acute obstruction due to carcinoma in the mid-sigmoid. Note absence of dilated small bowel in central field.

value as in the previous groups in demonstrating the presence of a mechanical ileus. However, a peculiar type of paralytic ileus unassociated with peritonitis, as well as severe cases of peritonitis, may give the same röntgenological picture as a mechanical obstruction. In a number of cases of paralytic ileus coming to autopsy it was noted that the terminal ileum was collapsed, and that the distension of the bowel increased steadily towards the duodenum. It can readily be understood how this type of ileus could give rise to a röntgenogram simulating a mechanical occlusion. Similarly, severe cases of peritonitis involving the small bowel may produce the same sort of picture.

The X-ray is of value, however, in determining the presence of an obstruction in clean cases where there is no question of peritonitis. In three such cases, one following a herniotomy, another a hysterectomy for fibroids, and the third a clean appendix, it led to immediate operative intervention. The fourth case was a drained appendix in whom the correct differential diagnosis between peritonitis and mechanical occlusion was accidentally made on grounds which we later learned were not certain.

The plain röntgenogram is of considerable value in ruling out the presence of a mechanical ileus. In five cases where the diagnosis of acute obstruction was seriously considered, the presence of gas in the colon dissuaded us from operative intervention. The subsequent course of these cases and an autopsy in one of them proved the correctness of the diagnosis.

To sum up, we feel that in the first week after operation the period during which paralytic ileus and peritonitis are most apt to occur, the diagnosis of mechanical occlusion of the small bowel requiring operative relief cannot be made with certainty by the X-ray. After this period, the presence of fluid levels in the small bowel, dilatation of the small bowel, and absence of gas in the colon may be taken as an evidence of mechanical ileus.

(4) *Obstruction due to spontaneous inflammatory bands.*—In one of these a loop of small bowel was caught underneath a band running towards a chronically diseased appendix. In the other one there was a twist due to an adhesion of a loop of bowel to a segment of omentum which was adherent to a small pro-peritoneal hernia. Both these patients were elderly men in whom the suspicion of colonic obstruction was strong. The röntgenogram successfully localized the obstruction to the small bowel.

(5) *Spontaneous volvulus of the terminal ileum.*—This patient was admitted with a short history, shock and a rigid abdomen. The admission diagnosis was perforated duodenal ulcer. X-rays taken for free air under the diaphragm revealed instead fluid levels in the small bowel. This permitted of more accurate diagnosis and the use of a more advantageously placed incision.

(6) *Tuberculous stricture of the mid-ileum.*—This patient had a history pointing to chronic intestinal obstruction which had suddenly become acute. The suspicion of colonic neoplasm was very strong. Röntgenograms, however, revealed that the obstruction was apparently in the small bowel.



FIG. 13



FIG. 14.

FIG. 13—Obstruction in the upper sigmoid by carcinoma with distension mainly present in the cæcum and ascending colon.

FIG. 14—Typical appearance given by gas-distended sigmoid in a case of sigmoid volvulus. Arrows point to vertex of volvulus.

(7) *Replacement of a gangrenous loop of small bowel by taxis on an irreducible hernia.*—The findings were typical of small bowel obstruction and led to laparotomy which revealed the above findings.

(8) Obstruction in a knuckle of gut in a small pro-peritoneal hernia in a woman seven months pregnant. Abdominal examination was naturally unsatisfactory and the diagnosis was considerably cleared up by the X-ray which showed dilated loops of small bowel.

(9) Two cases of strangulated partial enterocele (Richter's hernia). One of these occurred in a small femoral hernial sac in a very stout woman; the other in a small hiatus in the sigmoid mesentery. These cases are of unusual interest in that they were both passing small quantities of gas and the X-ray showed small quantities of

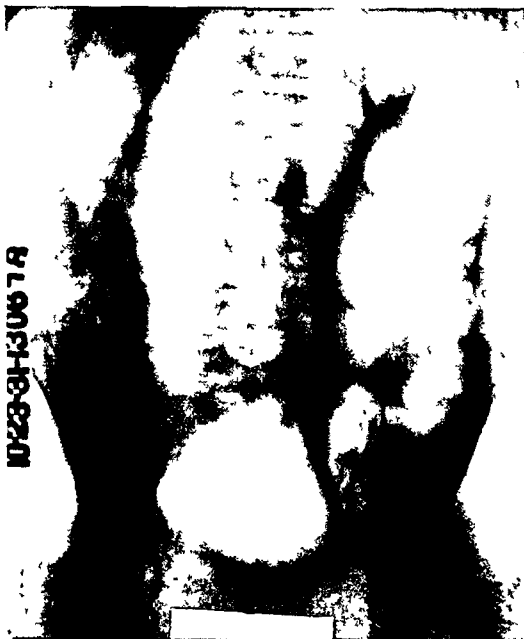


FIG. 15—An unusual picture in sigmoid volvulus showing both loops, usually only one loop of sigmoid can be visualized.

gas in the colon in addition to dilated loops of small bowel.

(10) *Two cases of intussusception in infancy.*—It is well known that

DIAGNOSIS INTESTINAL OBSTRUCTION

normally gas can be demonstrated in the small intestine of infants. However, gas is also usually present in the large bowel. In both of the present instances there were fluid levels, absence of gas in the colon, and dilated loops of small bowel.

(II) *Acute obstruction due to kinking of the ileum by an adhesion to a pyosalpinx.*—Two cases. Both these patients had large bilateral masses in the fornices. Inordinate vomiting led to the suspicion of mechanical obstruction and X-ray showed the findings typical of mechanical small bowel obstruction. Numerous control studies on cases of salpingitis and pyosalpinx made on the gynecological service of the Harlem Hospital through the kind coöperation of Doctor Falk, demonstrated that in the distension associated with pelvic inflammatory disease, gas was present either in the large bowel alone, or in both large and small bowel. The only exception noted in adnexal disease was in a diffuse peritonitis due to the rupture of a pus tube into the general peritoneal cavity.

One instance in which we were led astray was in a patient who was admitted to the hospital acutely ill, on the third day of her illness, with tender masses in both fornices. Inordinate vomiting and obstipation again led to the suspicion of mechanical obstruction. The X-ray showed fluid levels, dilated small bowel, and absence of gas in the colon. Laparotomy disclosed a diffuse peritonitis with paralytic ileus from a ruptured gangrenous appendix instead of a mechanical ileus, in addition to a bilateral pyosalpinx.

Paralytic and Reflex Ileus.—These are discussed at the present juncture because of the difficulty that they may offer in differentiation from mechanical small bowel occlusion. Practically this differential diagnosis is encountered mainly in the immediate post-operative phase. Our experiences may briefly be summarized as follows:

(1) *Peritonitis.*—(a) In severe cases of peritonitis with pus among the coils of ileum there may be a severe enough paralytic ileus to prevent the intestinal contents from reaching the colon. These patients will show dilated loops of small bowel, fluid levels in the small bowel, and absence of gas in the colon. Of course, röntgenological differentiation from mechanical ileus is impossible. This group is a small one and we have encountered it mainly immediately post-operatively and in cases of *known* peritonitis where control studies were being made. It has been our experience that most of these cases terminated lethally.

(b) In peritonitis of lesser severity gas may be demonstrated both in the colon and small bowel. These patients may also have fluid levels in the small bowel. The presence of the gas in the colon is an important factor in ruling out mechanical obstruction of the small bowel.

(c) In some types of post-operative distension the peritonitic process is mainly in the flanks, and gas may be present in large quantities only in the large bowel.

(2) *Paralytic ileus without peritonitis.*—In a number of patients coming to post-mortem following the development of symptoms of ileus immediately

post-operatively, the author has noted collapse of the terminal ileum with increasing distension extending orad and becoming quite marked in the jejunum. In one of these cases a mistaken diagnosis of mechanical ileus had been made by the röntgenogram for reasons which can easily be seen.

(3) *Reflex ileus*.—We have seen accumulations of gas in the small bowel and the presence of fluid levels in such diverse conditions as renal colic, obstructed ectopic kidney, retroperitoneal hæmatoma, and pancreatitis. We have also noted them at times following the introduction of ureteral catheters. (We do not wish to convey the impression that these are invariable findings. They are as a matter of fact the *unusual* findings.) The distension of the small bowel in these cases is never as marked as in obstruction or peritonitis and the overlying gas on top of the fluid level are frequently only slit-like. Furthermore, most of these cases also have gas in the colon, which serves to distinguish them from small bowel obstruction. In a number of these cases, as well as in some of the milder types of peritonitis, but never in mechanical ileus, gas could be demonstrated in the colon following an irrigation, when it had been absent previously.

Mechanical obstruction of the Large Bowel.—We consider it of great importance from a practical standpoint to distinguish pre-operatively between colonic and small bowel obstruction. Ileal or jejunal obstruction is either actually or potentially strangulatory and with few exceptions necessitates exploration and relief of the obstruction. Obstruction of the colon, except for the rare cases of sigmoid volvulus, and some types of intussusception, is obturating in nature and is usually on a neoplastic basis. These patients have been suffering as a rule from some degree of partial obstruction before the onset of total occlusion; they are chronically as well as acutely ill. Tension ulcers are frequently present proximal to the obstruction and in our experience the acute shut-down has in a number of instances been precipitated by the cedema around a sealed-off pin-point perforation in the region of the neoplasm. For these reasons, we feel that, by and large, the best results will be obtained in acute colonic obstruction by the performance of a good-sized cecostomy under local anæsthesia through a small incision, leaving the determination of the exact site, nature and operability of the lesion to be decided at some future time when the acute phase has passed off. On the other hand, unless one is absolutely sure that the obstruction is located in the large intestine, there is naturally considerable hesitancy in commencing a cecostomy upon a greatly distended patient through a small incision, poorly placed if exploration should be necessary, and with the unpleasant and dangerous eventuality in intestinal obstruction, of having to resort to general anæsthesia on the table. (The argument might be advanced that these difficulties could be largely obviated by the use of spinal anæsthesia. This is true. However, the induction of spinal anæsthesia by causing contraction and peristalsis of the bowel is to a great extent the equivalent of the administration of a powerful cathartic, and we have observed two cases where we

believe that tension ulcers in the cæcum and transverse colon were caused to perforate in this manner.)

The röntgenogram enables us to diagnose colonic obstruction with complete assurance. (Fig. 10 *et seq.*) The outlines of the distended colon proximal to the obstruction and the presence of fluid levels in it are unmistakable. (Figs. 11-15.) The site of the obstructive neoplasm was in the sigmoid in 12 instances. In 11 of these cases the entire large bowel was distended with gas and could be seen with unmistakable clarity. In the other case the distension was for some reason mainly localized to the cæcum and ascending colon. The splenic flexure, the transverse colon and the hepatic flexure were each the site of obstruction on one occasion. The obstruction was correctly localized in each instance by the flat plate. In the patient with the obstruction at the hepatic flexure, it was further verified by a barium enema and an ileo-transverse colostomy instead of a cecostomy was performed (the only time in this series) in order to leave a clean field for the secondary right-sided resection.

It is interesting to note that even in cases of long-standing obstruction of the colon, dilated small bowel or fluid levels in the small bowel, are not as a rule visualized. Another point worth mentioning is that in some cases of very prolonged obstruction there may be little gaseous distension. Thus in a case seen at another institution, and not included in this series, a patient who had been completely obstructed for two weeks from a tumor in the descending colon showed very little gaseous distension in the colon, but had a foamy appearance throughout the course of the large bowel, probably due to mixture of gas with semi-solid stool. At operation the colon was found to contain putty-like fæces.

Volvulus of the sigmoid was encountered five times in this series, an unusually high percentage. A definite diagnosis of volvulus of the sigmoid was made in four instances. In the other instance the diagnosis was simply that of obstruction of the large bowel. The plate in this instance was a poor one. The sigmoid is a relatively non-sacculated and non-haustrated portion of the colon, a fact which serves to distinguish it from other parts of the large bowel. When volvulus occurs the distension is practically limited to the twisted sigmoid loop. It achieves a distension much too enormous for small gut and can be seen to occupy a large portion of the abdominal cavity as a single well-defined loop. In one instance, both loops of the volvulus could be visualized as well as the base of the inverted U formed by the twisted gut. In the other cases only one of the limbs and the base of the U could be visualized.

CONCLUSIONS

(1) The plain röntgenogram of the abdomen without the use of contrast media is a distinct aid to the diagnosis of acute mechanical intestinal obstruction.

(2) It may be a decisive factor favoring operation in cases clinically doubtful.

(3) It may prevent exploratory laparotomy in patients with signs suggestive of ileus.

(4) It permits differentiation between large and small bowel obstruction.

(5) The cardinal signs of small bowel obstruction are: (a) Visualization of dilated loops of small bowel. (b) The presence of fluid levels in the small bowel. (c) Failure to visualize gas in the colon.

(6) Patients with symptoms of ileus in whom gas can be demonstrated in the colon are probably not suffering from mechanical occlusion of the small bowel.

(7) In the immediate post-operative phase caution must be used in differentiating mechanical obstruction from paralytic ileus or peritonitis, as all of these may give the same X-ray picture.

(8) The presence of fluid levels in the small bowel alone is not pathognomonic of mechanical obstruction. They have been encountered in peritonitis, in paralytic ileus, and in reflex ileus.

(9) Fluid levels and dilated loops of small bowel are probably not due to mechanical obstruction if there is coincident presence of gas in the colon.

(10) To reduce the chances of error it is advisable to take plates in the recumbent and erect positions.

(11) The diagnosis of colonic obstruction is easily made due to the marked distension of the colon proximal to the site of obstruction, and the presence of fluid levels with high vertical gas columns in it.

(12) Distended small bowel is not as a rule visualized in colonic obstruction.

(13) Localization of the obstruction in the colon is possible in a rough fashion. If necessary a barium enema may be used to confirm exact localization.

(14) Sigmoid volvulus can usually be diagnosed as such from X-ray appearance.

The author wishes to thank Dr. John F. Connors, Director of the Surgical Service at Harlem Hospital, for his permission to report the cases on his service. He is also indebted to Dr. A. A. Berg, Dr. Edwin Beer, Dr. Richard Lewisohn and Dr. Harold Neuhoof in permitting him to study the cases admitted to their respective services at the Mt. Sinai Hospital. To Doctor Jaches, of the Mt. Sinai Department of Radiology, and Doctor Snow of the Harlem Hospital, he is indebted for numerous courtesies.

BIBLIOGRAPHY

Kleiber, H.: Arch. fur Klin. Chirurgie, vol. cxii, p. 513, 1919.

Case, J. T.: ANNALS OF SURGERY, vol. lix, p. 715, 1924.

Ochsner, A. J., and Granger, A.: ANNALS OF SURGERY, vol. xcii, p. 947, 1931. (Contains an extensive Bibliography.)

CARCINOMA OF THE HEPATIC DUCT

By VERNON C. DAVID, M.D.

OF CHICAGO, ILL.

SCHNEPPEL is credited with being the first to describe carcinoma of the hepatic duct in 1878. Since then occasional reports of carcinoma of the biliary ducts have appeared in the literature. Rolleston's group of ninety-one cases is the largest and shows well the incidence in the different parts of the biliary duct system, excluding carcinoma of the ampulla and gall-bladder.

Common duct:	
Lower end	23
Middle	11
Junction, hepatic, common and cystic ducts	28
Common hepatic	19
Right or left hepatic	4
Cystic duct:	
Lower common duct	6

A number of interesting reports of carcinoma of the hepatic duct have been made. It has been pointed out (Kauffman) that the carcinoma may occasionally be villous or diffuse in character but that usually the growth is nodular and encircles the duct and converts it into a thick tube over a distance of one to two centimetres of its length. The size of the tumor varies from a pea-sized nodule to a swelling the size of a small hen's egg. Cases have been reported where the gastrohepatic ligament, pancreas, liver, portal vein or retroperitoneal glands have been involved but in the great majority of cases the growth is local and no evidence of metastases exists. Devic and Galfavardin found metastases in 20 per cent. of the cases they reviewed. Unlike carcinoma of the gall-bladder, gall-stones are found in only one-third of the cases. Histologically the tumor is composed of columnar cells, usually sparse in number, which are found embedded in great masses of fibrous connective tissue. It is the object of this communication:

(1) To call attention to the great similarity of the clinical course of carcinoma of the hepatic duct to common-duct stone where repeated severe colics, intermittency of the jaundice, non-dilated gall-bladder and chronicity of the course of the disease are characteristic.

(2) To emphasize the fact that at the operation the findings resemble but remotely those of common-duct stone and are characteristic of carcinoma of the hepatic duct in that the common duct and gall-bladder are normal, whereas the hepatic duct is converted into a firm, fibrous cord resembling in every way dense scar tissue. Unless this fact is known the diagnosis at operation is likely to be missed.

(3) To emphasize that when the stricture of the hepatic duct from carcinoma cannot be removed by operation and therefore jaundice continues that post-operative hæmorrhage is likely to occur and may be a fatal termination.

The report of the following two cases brings out these points:

CASE I.—I. H., male, sixty-eight years of age, seen with Doctors Billings, Post, and Thomas, entered the Presbyterian Hospital December 8, 1929; died December 17, 1929.

Present complaint.—For the past four days patient has had pain in right upper quadrant, dull in character, coming on after meals and often continuing all night. Deep jaundice has been present for three days and diarrhœa has been present for seven days. Stools are white. There has been no nausea or vomiting.

Past history.—One year ago patient had acute indigestion so severe that he fainted from the pain.

Examination.—Rather heavy man with negative physical findings except deep jaundice and acholic stools; liver rather firm and three fingers below the costal arch; gall-bladder not palpable. Fluoroscopic examination of stomach and bowel is negative. The flat X-ray plate of gall-bladder region shows several large stones.

Diagnosis.—Obstructive jaundice, gall-stones and probable common-duct stone.

Operation.—December 9, 1929, under ethylene-gas-ether anæsthesia. A right pararectus incision was made and a thick gall-bladder was encountered containing many stones and one large stone the size of a pigeon's egg which could not be dislodged from cystic duct. The gall-bladder was opened and split down to the cystic duct and the stone removed. It was then found that the hepatic duct was converted into a hard, fibrous mass reaching from the liver parenchyma downward for about $1\frac{1}{2}$ centimetres. The common duct was not dilated. The pancreas and stomach were normal. The incision was continued downward through the cystic duct into the common duct because of difficulty of bringing the common duct into the wound. There was practically no bile present in the common duct. A probe inserted upward through the common duct met firm obstruction in the hepatic duct. It was thought that the mass was scar tissue and produced by long-standing inflammation extending from the gall-bladder, which lay directly contiguous to it. After several minutes' examination with a probe a very small lumen was found in the hepatic duct and this was gently dilated by small forceps until a small catheter could be inserted through the stricture, where it was sutured into place. To our surprise but little bile was obtained and at no time after operation were there more than a few cubic centimetres of bile discharged. The gall-bladder was removed and the wound closed with cigarette drainage. Oozing of fresh blood from the wound began on the fifth day and persisted in spite of calcium administration and glucose by hypodermoclysis. On the sixth day 350 cubic centimetres of blood were transfused by the direct method. The wound was opened and packed. Five hundred cubic centimetres of blood were given by transfusion on the ninth day post-operatively without effect. In the evening of the ninth post-operative day the patient died.

The autopsy revealed a tubular constriction about $1\frac{1}{2}$ centimetres long, beginning at the junction of the right and left hepatic ducts. Above the obstruction the intra-hepatic ducts were widely dilated but contained little bile. There was slight extension of the carcinoma in the hepatic duct into the gastrohepatic ligament. No other evidence of extension of the growth or metastases was found. The intestinal tract contained a large amount of blood and there was a hæmorrhagic infarction of the duodenum.

Histologically, the lesion of the hepatic duct was a columnar cell scirrhous carcinoma. (Fig. 1.)

CASE II.—A. H., female, aged thirty-one. Entered the Presbyterian Hospital March, 1928, on the service of Dr. R. T. Woodyatt. She complained that since January, 1928, she had had three attacks of severe upper abdominal pain, radiating to the back under the right scapula. She vomited during the attacks. Hypodermics were necessary

CARCINOMA OF HEPATIC DUCT

to control the pain. During the attacks she thought that she became slightly jaundiced. On examination there were no unusual physical findings. The Wassermann was negative. No abdominal tenderness. Ten tablets of Iodekon gave no filling of the gall-bladder with dye. In June, 1928, she returned to the hospital with a history of repeated attacks of pain and jaundice after the attacks. The jaundice cleared between the attacks. She was tender and rigid over the right upper quadrant of the abdomen, white blood cells 16,300, red blood cells 3,930,000.

In July, 1928, she was operated upon in another city at which time the gall-bladder, which contained no stones, was removed. The common duct was opened without finding any stones or other pathology and was drained. After the operation she was greatly relieved and had no jaundice for about six months. At that time she had another attack with severe pain accompanied by jaundice. She became rather weak and nervous

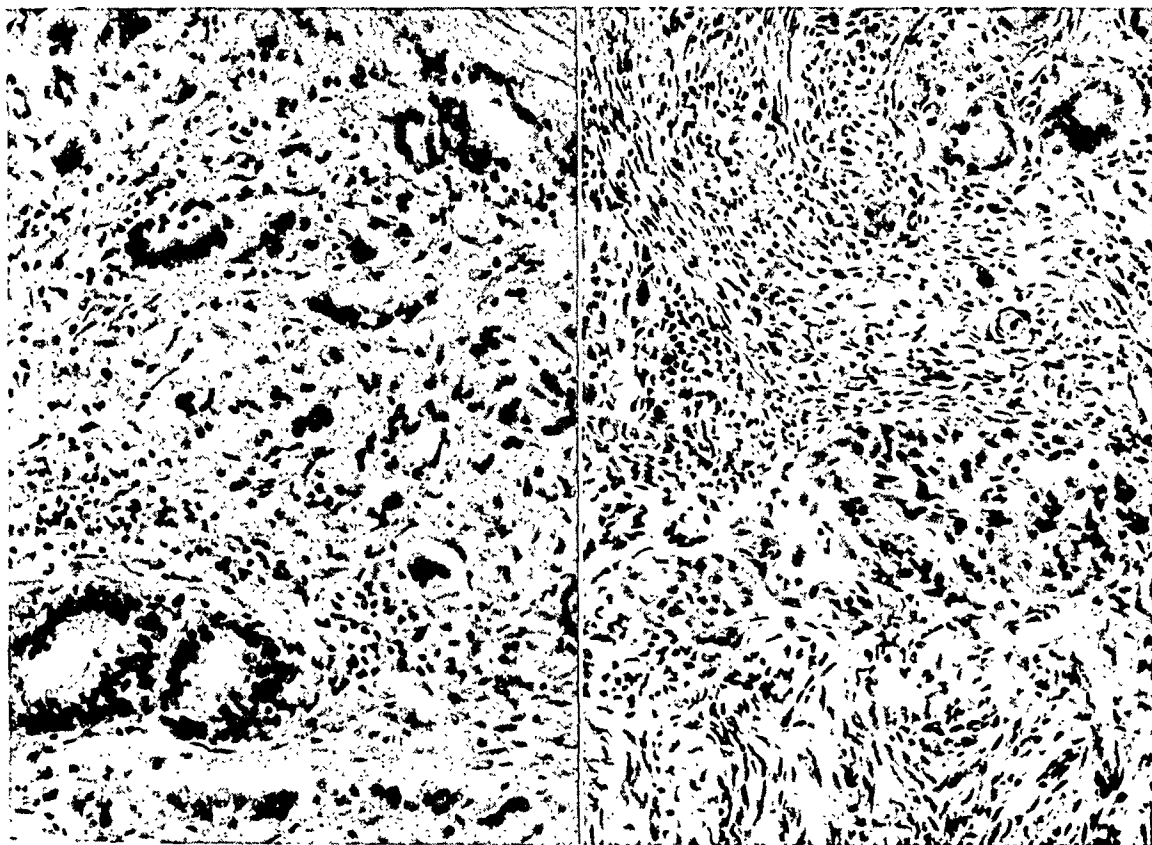


FIG. 1.—Case I. Scirrhus adenocarcinoma of the hepatic duct.

FIG. 2.—Case II. Scirrhus adenocarcinoma of the hepatic duct.

and developed tremor. On examination the liver margin was sharp. There were no intra-abdominal masses palpable. The basal metabolic rate was minus 11.

December, 1930, she returned to the Presbyterian Hospital with the complaint that she had severe pain in the region of the gall-bladder, lasting for three or four hours at a time. Just before Christmas, 1930, her jaundice cleared up, but in January, 1931, jaundice returned and she had a dull pain in the upper abdomen. She had no chills. Her stools had become clay colored and the icterus index rose from plus 16 to plus 45.

With the diagnosis of probable common-duct stone we advised reoperation and upon February 7, 1931, the old scar was removed, but great difficulty was encountered in getting into the peritoneum because of dense, fibrous adhesions obliterating the upper peritoneal cavity. The liver was densely adherent to the anterior abdominal wall. The upper abdominal contents were separated from the liver downward, the common duct was identified and when opened was found normal in size and a probe passed easily into the duodenum. The common duct, however, contained no bile. The probe passed

upward encountered an obstruction in the hepatic duct which was found to be due to a firm, fibrous thickening about the size of the terminal phalanx of the thumb, including the whole circumference of the duct. This mass was needled in many directions thinking that a stone might be found in the centre of the firm mass in the hepatic duct. No stone, however, was encountered. A small piece of the mass was removed for section and a diagnosis of carcinoma of the hepatic duct was made because of the similarity of the findings to those described in Case I. There were no enlarged glands, the liver was small and dark-green and contained no palpable metastases. A "T" tube was sutured into the common duct.

The second day after operation bile drained intermittently through the tube for several days. On the fifth day after operation there was marked oozing from the abdominal wall which continued for about a week. The patient remained deeply jaundiced, became weaker and died March 18, about five weeks after the operation.

The histological examination of the biopsy material showed dense scar tissue containing here and there small groups of epithelial cells. Our pathologist would not commit himself on the diagnosis though by physical findings at operation I felt confident that the mass was a carcinoma of the hepatic duct.

At autopsy the following pathological conditions were revealed: Scirrhus adenocarcinoma of the hepatic duct—no glandular metastases. Dilatation of the intrahepatic ducts. Suppurative cholangitis. Obstructive biliary cirrhosis. Marked emaciation. Extreme jaundice. Acute left pyelitis and acute cystitis. Encapsulated large nodule of tuberculosis in left lung. Small ovarian cyst. Patent foramen ovale.

THE PREDICTION OF HÆMORRHAGE IN OBSTRUCTIVE JAUNDICE BY THE SEDIMENTATION RATE

By HOWARD M. CLUTE, M.D.

AND

J. ROSS VEAL, M.D.

OF BOSTON, MASS.

OF THE LAHEY CLINIC

IT HAS long been recognized that patients with obstructive jaundice frequently tend to bleed either from wounds made during operation for the relief of their obstruction or spontaneously in the absence of any recognized trauma. This hæmorrhagic tendency has interested clinicians and laboratory investigators for many years, first because it renders any operative procedures on these patients extremely dangerous, second, because measures to prevent its occurrence, though long investigated, are inadequate in certain cases, and, finally, because there has been no positive way by which with laboratory tests or clinical examinations this tendency to bleed could be foretold.

Dr. Robert R. Linton,¹ in 1930, reported his opinion that the sedimentation rate of the red blood-cells could be used as an index of the hæmorrhagic tendency in obstructive jaundice. It is of particular clinical value in obstructive jaundice to know before operation is undertaken whether or not the patient will bleed. If, then, a simple test—the sedimentation rate of the red blood-cells—can be depended upon to give us this information, it will be of great advantage. After reading Linton's article, we have used this test in every patient with obstructive jaundice, both before and after operation, and it is our desire to present the results of these experiences at this time.

Opinions as to the cause of bleeding in obstructive jaundice differ widely. Wangensteen² has given a most comprehensive review of the literature upon this subject and in our opinion his deductions are logical. His article may be read with profit by anyone interested in this subject. Numerous factors have been considered as the cause of the hæmorrhagic tendency in jaundice; *i.e.*, the presence of the bile pigments and the bile acids in the blood-stream; a functional deficiency of calcium due to the increase in bile salts and bile acids in the urine and in the blood; and variation in the prothrombin and fibrinogen contents of the blood. None of these factors, however, can be proved experimentally as the sole cause of this tendency. It is probable, Wangensteen states, that normal coagulation of the blood is related to normal hepatic function and any destruction of liver tissue, combined with loss of function of the liver, directly alters the coagulation ability of the blood. It has been shown repeatedly that marked damage of liver structure results in failure of the blood to clot and it is known experimentally that extracts of liver tissue prevent the clotting of blood. It seems logical, therefore, to

assume that the chief factor in the tendency to bleed in obstructive jaundice is the presence in the blood-stream of products arising from the actual destruction of liver tissue and failure of liver function.

It is a fact that until Linton proposed the sedimentation rate there was no laboratory test which was a reliable index of the tendency to bleed in obstructive jaundice. It is common knowledge that estimation of the coagulation time of the blood and of the bleeding time are of no value in predicting the tendency to bleed. Thus in five of our cases the coagulation time and bleeding time were normal and yet serious hæmorrhage occurred. Conversely, in other cases the coagulation and bleeding time were prolonged and no hæmorrhage occurred. Lewisohn³ made a study of the blood-clotting factors in obstructive jaundice as proposed by Bancroft, Kugelmass and Stanley-Brown¹⁴ as an index of the tendency to bleed. For this purpose they estimate the prothrombin, the antithrombin and the fibrinogen of the blood and obtain a clotting index. The index is obtained by multiplying the prothrombin with fibrinogen and dividing it by the antithrombin. They state that if the index is .7 or above, the prognosis as to hæmorrhage is good, and when it is below .7 the tendency to hæmorrhage is definite. We have had no experience with this clotting index in jaundiced patients. It is an elaborate procedure, technically difficult and not readily performed. It has not as yet been done in a sufficiently large number of cases to warrant any conclusion.

Linton states that the sedimentation rate of the red blood-cells is apparently rapid in those patients with obstructive jaundice who tend to bleed and it is low or normal in those patients with no tendency to bleed. In the first studies of this reaction he reported seven cases of obstructive jaundice in which the sedimentation rate was rapid who had post-operative bleeding and ten other cases with normal slow rates who had no post-operative bleeding. It is desirable that further experiences, such as ours, shall be reported. If this relationship between the rapidity of the settling of the red blood-cells and the tendency to bleed is positive, the test is of very definite clinical value, since it has the great advantages of being simple to perform and inexpensive to do repeatedly.

It is well recognized that any one of innumerable factors may influence the sedimentation rate. Serious infection, fever, extensive malignancy, pregnancy, anæmia, exercise—all may effect the rapidity of settling of the red blood-cells. The possible presence of these factors in interpreting the tests must be considered. Our experience, however, has shown that fever is the chief complicating factor which one commonly encounters in obstructive jaundice that may affect the sedimentation rate. We, therefore, try to take the blood for sedimentation rate only in afebrile periods and to discount sedimentation rates taken when the patient had fever of marked degree.

The technic used in the laboratories of the New England Baptist Hospital and the New England Deaconess Hospital is that recommended by Plass and Rourke,⁴ as recorded by Linton, with certain slight modifications suggested by Miss Hazel Hunt, of the Deaconess Laboratory.

PREDICTION OF HÆMORRHAGE IN OBSTRUCTIVE JAUNDICE

The sedimentation tubes are specially prepared graduated glass tubes. (Fig. 1.) They hold from 1.11 to 1.18 cubic centimetres of blood and are

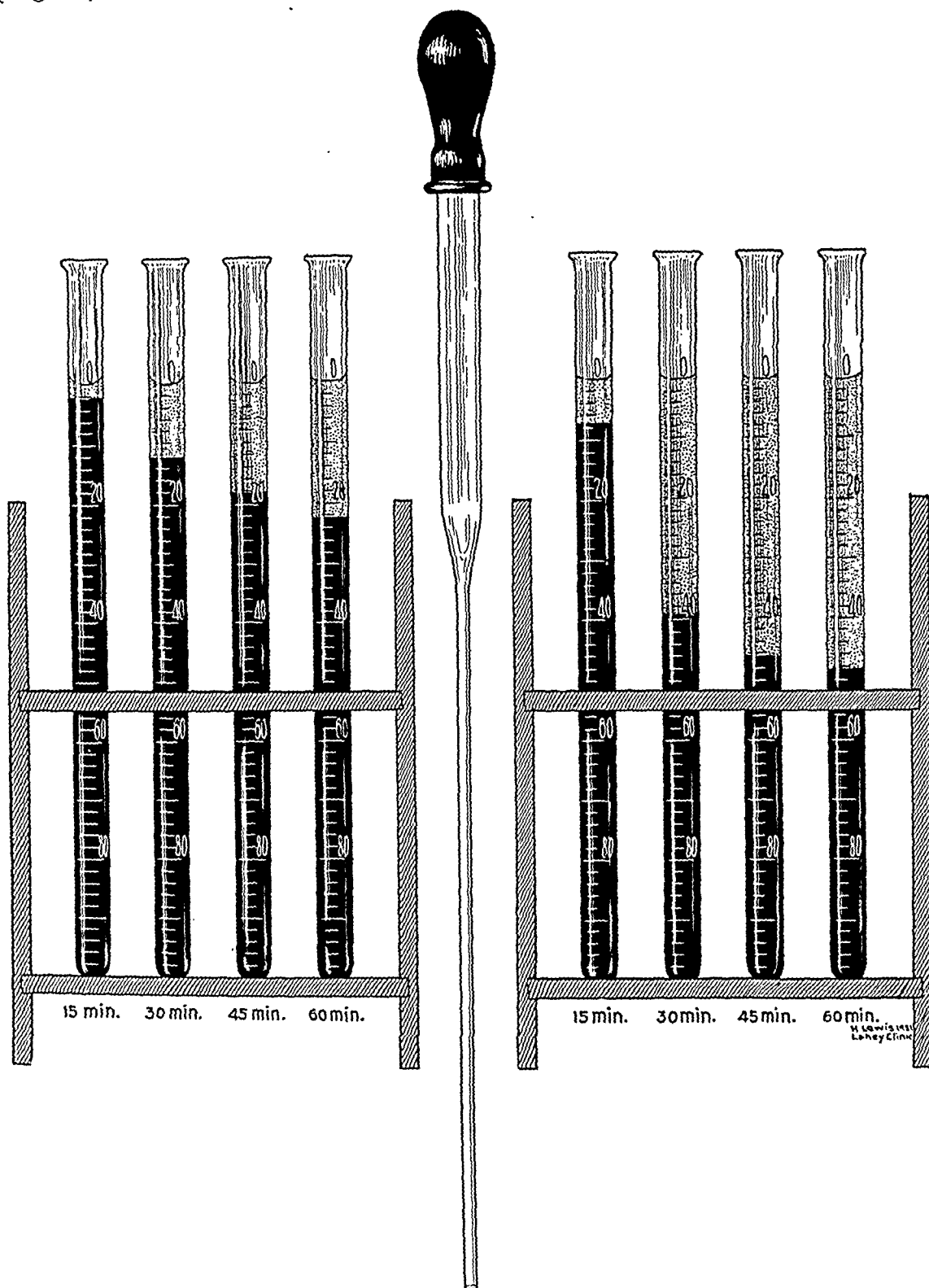


FIG. 1.—Drawing of two sets of sedimentation rate tubes with the blood-pictures as it would be at the varying intervals following the start of the test. On the left is seen the picture of the normal sedimentation of the red cells in a sixty-minute test. On the right is the sedimentation rate as seen when it is rapid. In the centre is the long thin pipette, devised by Miss Hunt for filling the sedimentation tube with blood and avoiding the presence of bubbles or air pockets.

graduated from zero at the top to one hundred at the bottom in millimetres. In their original work Plass and Rourke used calcium oxylate to prevent the

coagulation of the blood. Later they recommended the use of heparin. In this work potassium oxylate has been used.

Four cubic centimetres of venous blood are collected in the usual manner from a vein in the patient's arm and mixed with twenty milligrams of potassium oxylate. At the suggestion of Miss Hunt a long capillary pipette is used to transfer this blood to the sedimentation tube. The pipette reaches the bottom of the tube and from this point the filling of the tube is carried out. By this means the entrance of air bubbles and uneven filling is prevented. The tube is then placed in a test-tube rack and readings of the amount of the settling of the red blood-cells in millimetres are made directly from the tube every fifteen minutes for one hour.

Linton arbitrarily adopted the reading at the end of thirty minutes as the desirable reading from which to draw his conclusions of the rapidity of the sedimentation process. In a normal individual the red blood-cells tend to settle slowly and thirty millimetres may be considered the normal high point for the settling of these cells after a thirty-minute interval. (Fig. 1.) If the cells have settled more than thirty millimetres in thirty minutes the sedimentation rate may be considered rapid and if they have settled less than thirty millimetres in thirty minutes the sedimentation rate may be considered slow or normal. From our experience we believe that forty millimetres may be taken as the limit of normal sedimentation in jaundiced patients, which is somewhat higher than the figure recommended by Linton.

We have studied twenty-six cases of obstructive jaundice due either to stones in the common duct, malignancy involving the common duct or stricture of the common duct in relation to the effect of the jaundice on sedimentation rates. On careful analysis of these twenty-six cases, we have found that there are insufficient data on eight patients to warrant any conclusions being drawn. This leaves us, therefore, with eighteen patients in whom we consider we have sufficient information to warrant deductions.

In seven of the eighteen patients the sedimentation rate was rapid, rising in each instance to fifty or above in thirty minutes. In six of these seven cases bleeding occurred and in one no bleeding was noted.

In eleven of the patients the sedimentation rate was either low or only slightly elevated above thirty. In ten of these cases no bleeding occurred. In one, slight oozing from the incision, from the common duct, from the bladder and from the alimentary tract was present for three days.

From the above it is at once evident that the sedimentation rate is not an absolutely positive test for the tendency to bleed in obstructive jaundice since bleeding occurred once when the rate was slow and failed to occur in one case when the rate was rapid. It is desirable to consider particularly the two exceptions to Linton's findings. In one case, No. 24532, the rate became rapid post-operatively yet no bleeding occurred. This patient had obstructive jaundice and also a severe cholangiitis due to a duodenal ulcer involving the pancreas and common duct. Whether jaundice arising from hepatic infection produces a different effect on the sedimentation rate than simple obstructive

jaundice is not known. This patient had from one to two degrees of fever when his rate was rapid but we have not previously seen as marked an increase of sedimentation rate with such slight elevation of temperature.

The second case, No. 10,326, in this series in which the sedimentation rate did not accurately predict the tendency to bleed was the converse of the one just stated. This patient had severe jaundice due to a large common-duct stone and also an infectious cholangitis. Her jaundice persisted for many weeks after the obstruction was removed. Her sedimentation rate on admission was slow but before operation it was 46. Post-operative bleeding was predicted and therefore she was transfused the day before operation and the day of operation with whole blood. Following operation the rate fell to a low figure and remained at this level. On the sixth post-operative day, however, slight oozing occurred from the wound and blood was passed in the urine and by coughing. A third whole blood transfusion was given which controlled the bleeding at once. No further hæmorrhage has occurred in spite of jaundice persisting for several weeks after operation. The sedimentation rate has remained slow all this time. This patient must doubtless be considered an exception to the rule yet one must note that her rate was rapid before operation and from this bleeding was predicted. The bleeding, however, occurred six days after two transfusions and in the presence of a slow sedimentation rate repeatedly and carefully checked.

The chart in Fig. 2 shows the sedimentation rates of the seven patients who bled following operation for their obstructive jaundice. On the chart are noted the sedimentation rate, the days of operation, the time of bleeding, and the results following transfusion of either citrated blood or whole blood. The first patient who bled, No. 11,902, had a hopeless stricture of the common hepatic duct with serious jaundice of long duration. It is important to note that her bleeding and coagulation time were normal, that her sedimentation rate rose rapidly after operation and that bleeding occurred soon after operation. One may note that with whole blood transfusion the sedimentation rate dropped somewhat but soon rose again and at the same time more serious bleeding arose which finally was the cause of a fatal result. This patient had been jaundiced for many months and her condition was considered a hopeless one because of the location of the stricture.

The second case on the chart, No. 23,075, had normal bleeding and coagulation time on entrance to the hospital. The sedimentation rate at the time of operation was moderately increased and therefore a citrate blood transfusion was done after the operation. Post-operatively bleeding occurred and at this time the sedimentation rate was noted to be sixty-two, which is definitely rapid. A whole blood transfusion was now given and immediately following this the bleeding ceased. Within three days the sedimentation rate fell rapidly and no further bleeding occurred.

In the third case, No. 23,529, we had another hopeless stricture of the common duct with jaundice of long duration. Here, again, the bleeding time and coagulation time were normal on admittance to the hospital, but the sedimentation rate was rapid at the time of the operation. A whole blood transfusion was given and the sedimentation rate came down. On the fifth day after operation bleeding occurred. It is to be noted that the sedimentation rate had risen constantly and was 54 at the time of bleeding. Here, again, whole blood transfusion was given with some improvement which was, however, only transient. The sedimentation rate continued to be rapid, bleeding persisted and was not checked by two more citrate blood transfusions. The patient died ten days after opera-

CLUTE AND VEAL

tion. It is of interest to note here that at the height of the bleeding, with a rapid sedimentation rate, the coagulation time and bleeding time were again taken and found to be normal.

In case No. 20,632 the sedimentation rate was 40, which is definitely rapid at the time of operation. Transfusion here was done following operation and in spite of this the sedimentation rate rose to 50 and hæmorrhage occurred. Two transfusions of whole blood were then performed at three-day intervals, the bleeding stopped and the sedimentation rate dropped to 10. Ten days after the last transfusion bleeding again occurred and at this time the sedimentation rate was rapid. Transfusion was used to check the bleeding and coincidentally the sedimentation rate became slow. The patient had no further bleeding during her convalescence. It is to be noted in this chart that the sedimentation rate rose a few days after her last hæmorrhage, when a subphrenic abscess developed. By this time, however, the jaundice had entirely cleared and no further complications relating to bleeding were present. With drainage of the subphrenic abscess the patient made a most satisfactory convalescence.

In case No. 23,333 there is a marked drop in the sedimentation rate in the three-day interval spent in the hospital before operation from 42 to 24. At operation a whole blood transfusion was given and no immediate post-operative bleeding occurred. On the fifth day, however, a small amount of bleeding was noted in the wound and at this time, furthermore, the sedimentation rate was very definitely elevated to 62. Because the bleeding was so slight, transfusion was not done immediately but the patient was given increased fluids and glucose by veins and subpectorally. With twenty-four hours the ooze from his wound stopped and the patient made an uneventful convalescence. Coincident with the cessation of bleeding the sedimentation rate fell to 28.

In case No. 60,715 serious bleeding occurred and was undoubtedly one of the chief factors causing a fatal result. This patient had an obstructive jaundice proven at autopsy to be due to a high stricture at the junction of the right and left hepatic ducts. At operation a gall-bladder full of stones was removed; the common duct was small and thin-walled. It was explored. No stones were present and the stricture was not discovered. After operation the jaundice persisted and deepened and death occurred fourteen days later. The sedimentation rate correctly predicted the hæmorrhagic tendency in this case as is seen on the chart. It rose rapidly following operation and coincidentally hæmorrhage occurred.

In these patients who bled we have been increasingly impressed with the necessity of whole blood transfusions to control the bleeding. Citrate transfusions were used three times for the control of hæmorrhage in these patients and in none of these instances did the hæmorrhage stop after this treatment. On the other hand, nine whole blood transfusions were used in this group of patients and in no instance did this fail to control the bleeding for an appreciable time. We feel, therefore, from our recent experience, that whole blood transfusions rather than citrate transfusions should be used in the preparation of patients for operation with a tendency to bleed and in the treatment of hæmorrhage following operation in obstructive jaundice.

Eleven patients in this series had no hæmorrhage following the relief of their obstructive jaundice. Their charts with the daily sedimentation rates and the times of operation are shown herewith. (Fig. 3.) The sedimentation rate in six of these patients was elevated somewhat above 30 at the time of operation, yet in none of these patients did even the slightest bleeding occur.

Case No. 23,832, a cancer of the gall-bladder involving the cystic and common ducts, had a rapid rate on admission which was still rapid in spite of pre-operative treatment with fluid and glucose at the time of operation. Following operation he was transfused with whole blood. Within a few days the rate returned to normal and at no time did any bleeding occur.

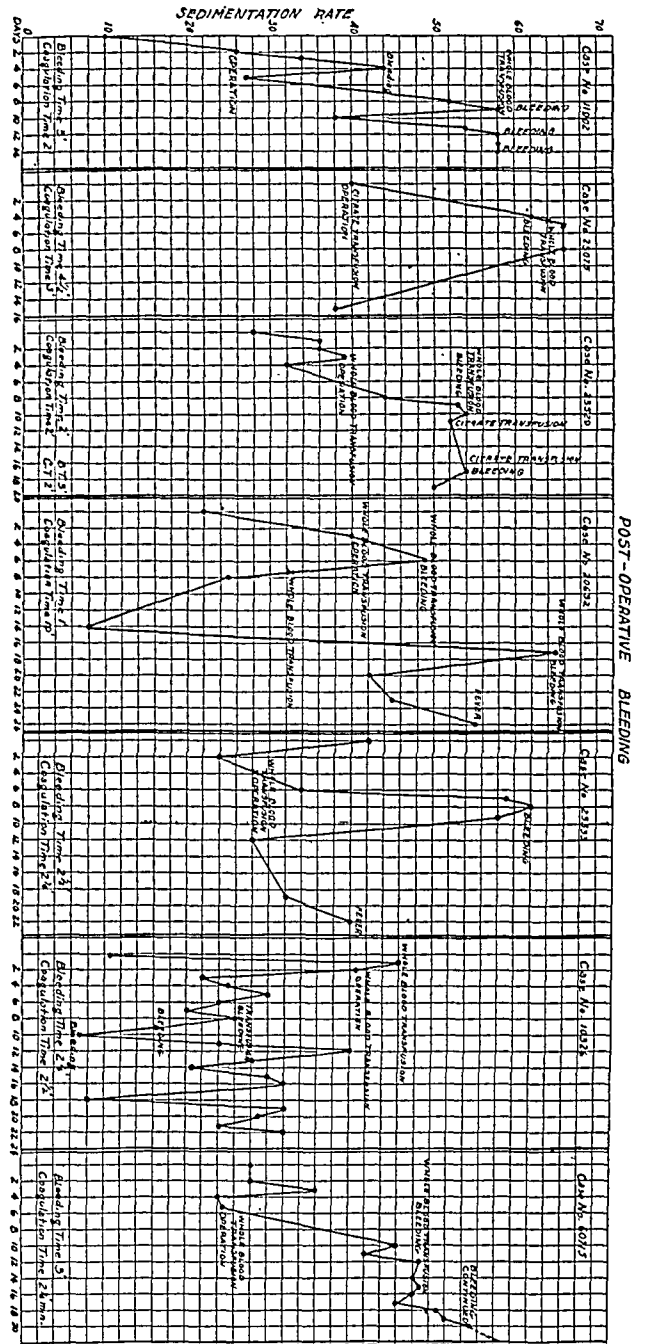


FIG. 2.—Chart showing the sedimentation rates, time of operation, transfusions of blood, either whole or citrate, and the time of bleeding, in the seven cases who bled after operation. Note that the sedimentation rate is rapid in all of these save one—Case 10,326, a patient with common-duct stones and fatal cholangitis.

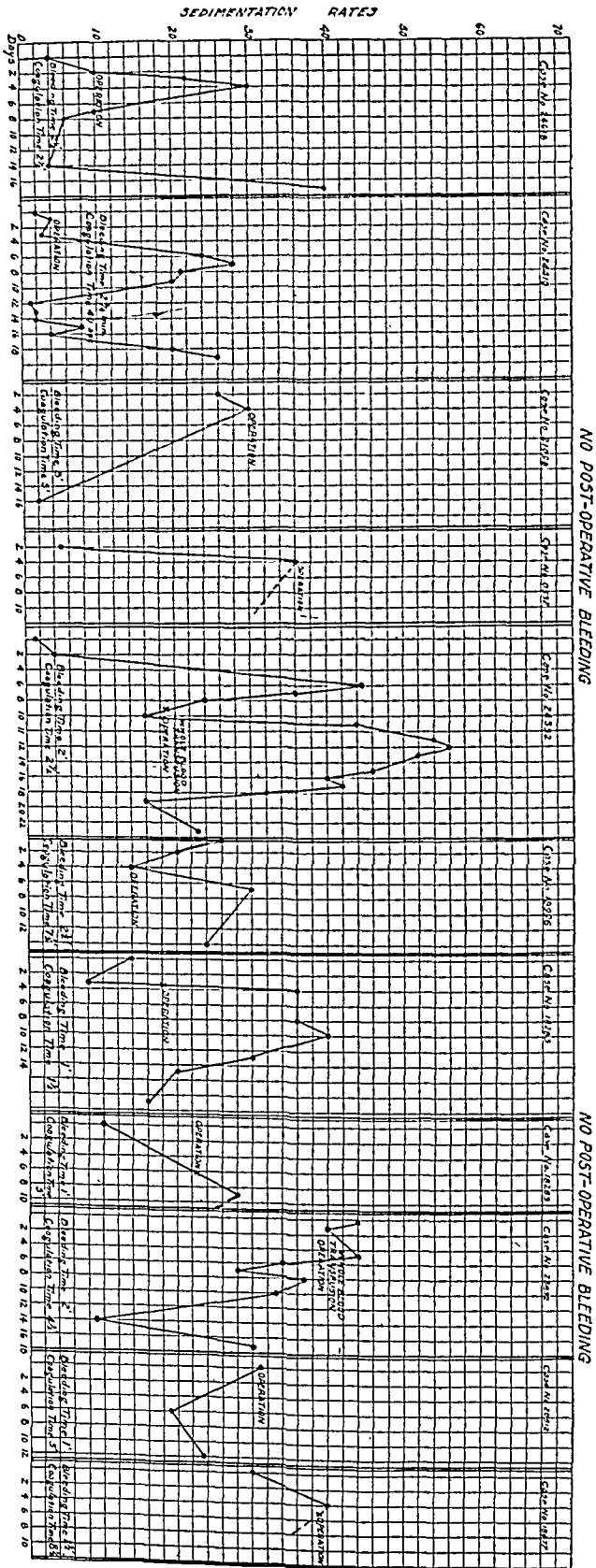


FIG. 3.—The sedimentation rate, time of operation and treatment in eleven patients in whom no post-operative bleeding occurred. Note that the sedimentation rate was relatively slow in all these patients save one—Case 24,532, a patient with a duodenal ulcer and cholangitis on whom a cholecystgastrostomy was done.

We may summarize our experience with the sedimentation rate as an index of the tendency to bleed in obstructive jaundice as follows. In eighteen patients with obstructive jaundice bleeding occurred seven times and no bleeding occurred eleven times. Nine of the patients had sedimentation rates which were above 40 but only seven were persistently elevated above this level. Of the seven patients who had definitely accelerated rates six bled and one did not. In those patients in whom the rate was low, ten had no bleeding and one patient bled.

It is of interest to note that the exceptions in each group who failed to follow the course predicted by Linton had, in addition to the obstruction of the common duct, an infectious jaundice of severe degree. Thus in the one low sedimentation rate case who bled, infectious jaundice was a prominent feature for many weeks. In the one patient with rapid sedimentation rate who did not bleed, infectious jaundice was a large part of the post-operative difficulty. We do not feel that these cases can be excluded, however, from the group under consideration since they had definitely obstructed common ducts in addition to their cholangiitis. If the test is not sufficiently inclusive to permit us to predict bleeding in patients who have cholangiitis in addition to obstruction, this factor must be considered in the interpretation of the test in each case.

For some time in our early study of this test we felt a considerable confidence that a rapid rate meant hæmorrhage would surely occur and a slow rate meant no bleeding would occur. More recently, however, as our experience has increased and our number of cases has grown, we have been greatly disappointed to find definite exceptions to the above prediction. We feel, therefore, that, although the test is very suggestive, much more study and experience are necessary before any final conclusions can be drawn. At present we do not believe that the sedimentation rate can be taken as positive evidence of the tendency to bleed in obstructive jaundice. Our experience would warrant the assumption that in all probability the rate will suggest the post-operative tendency, but that it cannot be depended upon as an absolute criterion. In spite of this fact we feel this test is of definite clinical help in predicting hæmorrhage in obstructive jaundice.

BIBLIOGRAPHY

- ¹ Linton, Robert R.: The Sedimentation Rate of Blood as an Index of the Hæmorrhagic Tendency in Obstructive Jaundice. *ANNALS OF SURGERY*, vol. xci, No. 5, pp. 694-704, May, 1930.
- ² Wangenstein, Owen H.: The Hæmorrhagic Diathesis of Obstructive Jaundice and Its Treatment. *ANNALS OF SURGERY*, vol. lxxxviii, No. 5, p. 845, November, 1928.
- ³ Lewisohn, Richard: Hæmatologic Studies as a Basis for Determining the Risk of Post-operative Hæmorrhage in Jaundice Patients. *ANNALS OF SURGERY*, vol. xxiv, July, 1931.
- ⁴ Plass, E. D., and Rourke, M.D.: A New Procedure for Determining the Blood Sedimentation Rate. *Jour. of Clin. Investigation*, vol. v, p. 531, 1927, 1928.

PREDICTION OF HÆMORRHAGE IN OBSTRUCTIVE JAUNDICE

- ⁶ Ravdin, I. S., Riegel, and Morrison: Coagulation of Blood. The Comparative Values of Calcium and Glucose as Agents for Decreasing the Clotting Time. *ANNALS OF SURGERY*, vol. xcl, No. 6, p. 801, June, 1930.
- ⁹ Linton, Robert R.: The Relation of Calcium to the Hæmorrhagic Tendency in Obstructive Jaundice. *ANNALS OF SURGERY*, vol. xciii, No. 3, March, 1931.
- ⁷ Zimmerman, Leo M.: Effect of Parathyroid Hormone on Blood Coagulation with Special Reference to Jaundice. *Amer. Jour. Med. Sci.*, vol. clxxiv, p. 379, 1927.
- ⁸ Walters, W.: Obstructive Jaundice: Its Surgical Aspect. *ANNALS OF SURGERY*, vol. xciii, p. 1137, 1931.
- ⁹ Rosenthal, and Blowstein: The Sedimentation Time of Blood in Jaundice. *Jour. Lab. and Clin. Med.*, vol. xiv, p. 464, February, 1929.
- ¹⁰ Greisheimer, Esther M.: The Sedimentation Rate in Normal Men and Women. *Amer. Jour. Med. Sci.* vol. clxxiv, pp. 338-343, September, 1927.
- ¹¹ Cordua, R., and Hartman, H.: On Quickening of the Coagulation and Settling of the Blood. *Klin. Woch.*, vol. v, No. 49, pp. 2309-2311, December 3, 1926.
- ¹² Rubin, E. H.: The Sedimentation Reaction in Cancer. *Amer. Jour. Med. Sci.*, vol. clxxiv, pp. 680-690, November, 1927.
- ¹³ Polak, J. O., and Tollefson, D. A.: Clinical Significance of the Sedimentation Test. *Jour. of the Amer. Med. Assn.*, vol. xc, pp. 168-171, January 21, 1928.
- ¹⁴ Bancroft, F. W., Kugelmass, J. N., and Stanley-Brown, Margaret: *ANNALS OF SURGERY*, vol. xc, p. 161, 1929.

THE RELATION OF THE BLOOD FIBRIN TO THE HÆMORRHAGIC DIATHESIS OF OBSTRUCTIVE JAUNDICE

BY ROBERT R. LINTON, M.D.

OF BOSTON, MASS.

FROM THE SURGICAL SERVICES OF THE MASSACHUSETTS GENERAL HOSPITAL

THE hæmorrhagic tendency in patients with obstructive jaundice has long been recognized. As yet there has been no adequate explanation of the cause of this predisposition to hæmorrhage. It is not known whether some factors necessary in the coagulation of the blood are deficient, or whether there is an increase in some of the anti-coagulants normally circulating in the blood.

For a number of years the blood calcium was thought to be deficient, or to exist in a form unavailable for the clotting of the blood. Recent investigations,^{1, 2} however, have thrown much doubt on this theory. A number of investigators have shown there is no deficiency, either qualitatively or quantitatively, in the blood calcium. Other theories of the cause of the bleeding tendency such as an accumulation of bile-salts or bile-pigments have also been disproven.^{3, 4, 22}

At the present time none of the methods in use to prevent or correct the hæmorrhagic tendency, by the administration of drugs, is grounded on sound scientific basis. The most effective means of control is the repeated transfusion of whole blood. In some cases even this fails and the patient dies from uncontrollable hæmorrhage. Whether it is the addition of normal platelets, or other elements necessary for coagulation, which controls the bleeding in some of the cases, is not known. The various methods, including the use of calcium chloride intravenously, have proven inadequate in a great many cases.² Attempts to improve the liver function by means of a high carbohydrate and fluid intake are of importance both pre-operatively and post-operatively, but if hæmorrhage has commenced these measures are of little immediate value.

The Blood Fibrin in Severe Liver Disease.—The blood fibrin is one of the important elements in the coagulation of the blood. The chief and perhaps sole source of it is the liver. In the hæmorrhagic diatheses associated with severe liver destruction, produced experimentally by phosphorus or chloroform poisoning, there is a marked diminution of the blood fibrin. This decrease is thought to explain the diminished coagulability of the blood in marked parenchymal liver damage. In obstructive jaundice of long standing there has been shown to be considerable parenchymal liver damage.^{11, 12} Because of these facts, I have investigated the blood fibrin in a group of patients with obstructive jaundice, to see if a diminution in this substance may play a rôle in the associated hæmorrhagic diathesis.

According to Melchior,¹⁰ Wunderlich, about seventy-five years ago, noted bleeding in cases of phosphorus poisoning, cholangitis, carcinoma of the liver parenchyma and in

BLOOD FIBRIN IN HÆMORRHAGE OF JAUNDICE

jaundice, and it is reported that he found a decrease of the fibrin in these cases. In 1894 Corin and Ansiaux,⁶ working with phosphorus poisoning, concluded that the incoagulability of the blood was due to a decrease in the fibrin. In 1900 Jacoby¹⁸ corroborated this work. Later in 1905 Doyon⁷ and his co-workers showed that there was a similar decrease of the fibrin and an associated incoagulability of the blood, in chloroform poisoning. They thought this reduction of the fibrin in both phosphorus and chloroform poisoning was due to a toxic action on the liver.

In 1911 Whipple and Hurwitz⁸ confirmed the work of Doyon on chloroform poisoning. Later in 1921 Foster and Whipple,⁹ continuing the work, also found a decrease of the fibrin following severe liver damage and associated with this, a marked incoagulability of the blood. They also noted that the fibrin returned to normal as hepatic repair occurred. Schultz *et al.*¹⁰ recently confirmed this hæmorrhagic diathesis in severe liver damage, which is apparently explainable by the diminished blood fibrin.

Normal Blood Fibrin.—The normal blood fibrin level varies considerably according to the figures reported in the literature. Foster¹⁴ states that variations of approximately 15 per cent. above or below the average are to be considered within normal limits. The normal fibrin values for humans are given in Table I. These four sets of figures seem to be the most reliable that have been reported in the literature. The average number of milligrams of fibrin per 100 cubic centimetres of blood and plasma, according to the above set of figures, vary respectively from 155 to 172 and from 280 to 338. The mean values are 166 milligrams of fibrin per 100 cubic centimetres of blood and 321 milligrams per 100 cubic centimetres of plasma.

TABLE I
Normal Fibrin Values (Human)

Investigator		Fibrin per 100 cc. Plasma	Fibrin per 100 cc. Blood
Gram, ¹³ 50 determinations	{ Maximum	370	200
	{ Minimum	205	115
	{ Average	280	155
Foster, ¹⁴ 42 determinations	{ Maximum	457	221
	{ Minimum	256	127
	{ Average	338	171
McLester, ¹⁵ 15 determinations	{ Maximum	385	...
	{ Minimum	272	...
	{ Average	333	...
Foster, and Whipple, ¹⁴ 4 determinations	{ Maximum	364	178
	{ Minimum	316	163
	{ Average	335	172

Blood Fibrin in Obstructive Jaundice.—Blood-fibrin values in obstructive jaundice have been reported by several investigators. These have been isolated determinations in the majority of instances.

Whipple, and Hurwitz⁸ in 1911 noted in a dog with complete obstruction of the common bile-duct there was a slight elevation of the blood fibrin at the end of two weeks. Gram¹³ in 1922 reported seven blood and plasma fibrin determinations in four cases of obstructive jaundice due to carcinoma of the pancreas and bile-ducts. All of

these figures are several times the normal value, but he did not mention the incidence of hæmorrhage. Foster¹⁴ in 1924 reported the blood- and plasma-fibrin values in two cases of obstructive jaundice. In both cases the values are above normal. McLester and co-workers¹⁰ reported in 1925 fibrin studies in liver disease but did not include cases of obstructive jaundice. Weltmann and Neumayer²¹ in 1925 reported from Germany the fibrin values in fifty-six patients with liver diseases. Twenty-seven of these showed increased values. They were chiefly cholelithiasis and neoplasm. Twelve others had normal values and the remaining seventeen had reduced determinations. The latter were chiefly diseases of the liver parenchyma. Baumann²⁰ in 1930 from Germany reported fibrin values well above normal in two cases of acute yellow atrophy, and two cases of carcinoma of the head of the pancreas with obstructive jaundice. The former bled to death post-operatively, one of the others bled post-operatively, and the fourth case developed hæmorrhages spontaneously. In addition to the above, several European investigators, including Wildegans,²² Murakami, and Yamaguchi,²³ Isaac-Krieger, and Hiege,²⁴ and Schultz, and Scheffer²⁵ reported fibrin values in patients and animals with obstructive jaundice, but their results are of questionable value, because the method they used is not a quantitative one. It was described by Wohlgemuth²⁶ in 1910.

Method of Fibrin Determination.—There are several methods by which the blood fibrin may be determined. Schultz *et al.*¹⁰ give a complete list of references. The most practical method is to change the fibrinogen to fibrin by causing the plasma to clot. This clot is readily handled and the amount of it may be determined either gravimetrically or by means of the Kjeldahl method. The determination of the fibrin by gravimetric means compares accurately with direct determination of the fibrinogen by precipitation with sodium sulfate,¹⁷ and also with other methods.⁵

The method I have found the most satisfactory is the gravimetric method originally described by Foster, and Whipple⁵ and later modified by Schultz *et al.*¹⁰ I have added another slight modification. Instead of a 2 per cent. solution of sodium oxalate as an anti-coagulant employed in the collection of the blood, I have used a dry-powdered anti-coagulant. The advantage of this is that in computing the fibrin values and reading the hæmatocrit values one does not have to take into consideration any correction because of dilution of the sample of blood, due to the anti-coagulant.

The method I used in detail is as follows: Five to seven cubic centimetres of blood are withdrawn from a vein by syringe and needle. The blood is immediately put in a small bottle containing approximately 14 milligrams of powdered potassium oxalate. A thorough mixing by shaking the bottle prevents coagulation. The plasma is separated from the red corpuscles by centrifugalization. This is done in a graduated tube, so that the hæmatocrit reading is obtained. Two cubic centimetres of the clear plasma are then drawn off with a pipette, and mixed in a 50 cubic centimetre centrifuge tube with 40 cubic centimetres of a clotting solution containing 0.8 per cent. sodium chloride and 0.125 per cent. calcium chloride.

After a period of two to three hours at room temperature or twelve hours in the ice box, the fibrin of the plasma forms a coagulum. This is freed from the side of the tube with a glass rod. It is then collected either by means of a fine glass rod by which the fluid may be expressed from the fibrin, or as Schultz *et al.*¹⁰ describe, by means of high-speed centrifugalization in which case the fibrin is compressed into a small white button. Some of the coagulums are so friable that the glass rod breaks them into many pieces. This makes the fibrin extremely difficult to collect by this means. In these

BLOOD FIBRIN IN HÆMORRHAGE OF JAUNDICE

cases I found centrifugalization is the best mode of collection. The tough coagulums are more easily collected with a glass rod.

The next step is to press the fibrin between filter paper to express the excess water. The small pellet of fibrin is then transferred to a porcelain crucible and dried for one to two hours in an oven at 110° C. After cooling in a desiccator the crucible and fibrin are weighed carefully. The fibrin is then burned by placing the crucible over a Bunsen burner for five minutes. The crucible and ash are again cooled in a desiccator and then weighed. The difference in weight represents the amount of fibrin in 2 cubic centimetres of plasma. From this figure the amount of fibrin per 100 cubic centimetres of plasma and blood are readily computed by the following formulæ:

$$\frac{\text{Milligrams fibrin in 2 cubic centimetres of plasma} \times 100}{2} =$$

Milligrams of fibrin per 100 cubic centimetres of plasma

and

$$\frac{\text{Milligrams fibrin in 2 cubic centimetres of plasma} \times \text{percentage of plasma}}{2} =$$

Milligrams of fibrin per 100 cubic centimetres of blood.

Clinical Observations.—Blood fibrin studies were carried out on a series of fifteen patients with obstructive jaundice. (Table II.) Six had carcinoma of the pancreas occluding the common bile-duct, two carcinoma of the gall-bladder involving the common bile-duct, three hepatitis and an associated cirrhosis, one cirrhosis of the liver, one metastatic carcinoma of the liver involving the common bile-duct, one carcinoma of the ampulla of Vater, and one case of cholelithiasis with obstructive jaundice. The patients' ages varied from thirty to sixty-three years. The minimum duration of the jaundice was one week and the maximum was ten weeks. Eight cases had jaundice of six or more weeks' standing. The minimum degree of jaundice measured by the quantitative van den Bergh test was 12 milligrams of bilirubin per 100 cubic centimetres of serum and the maximum was 31 milligrams, indicating in all cases a high degree of obstructive jaundice.

Thirteen of the fifteen cases were operated upon. In five cases, exploratory laparotomy was the only operative procedure. Seven of the patients developed post-operative bleeding. In three of these, hæmorrhage played a major rôle in the cause of death, and in the other four it was of less importance, but a contributing factor.

TABLE II

Fibrin Values in Obstructive Jaundice

CASE I.—Diagnosis.—Carcinoma of gall-bladder with obstructive jaundice. Female, fifty-seven years old. Duration of jaundice.—7 weeks. Degree of jaundice.—18.75. Blood fibrin.—219-490. Plasma fibrin.—300-700. No. of determinations.—2. No hæmorrhage.

CASE II.—Diagnosis.—Carcinoma of gall-bladder with obstructive jaundice. Female, fifty-four years old. Duration of jaundice.—2 weeks. Degree of jaundice.—13.5. Blood fibrin.—527-1046. Plasma fibrin.—800-1275. No. of determinations.—4. No hæmorrhage.

CASE III.—Diagnosis.—Carcinoma of pancreas with obstructive jaundice. Female, forty-eight years old. Duration of jaundice.—6 weeks. Degree of jaundice.—30.0. Blood fibrin.—487-568. Plasma fibrin.—650-800. No. of determinations.—2. Hæmorrhage one plus.

CASE IV.—Diagnosis.—Carcinoma of pancreas with obstructive jaundice. Male, forty-nine years old. Duration of jaundice.—2 weeks. Degree of jaundice.—12.0. Blood fibrin.—357. Plasma fibrin.—700. No. of determinations.—1. No hæmorrhage.

CASE V.—Diagnosis.—Carcinoma of pancreas with obstructive jaundice. Male, thirty-eight years old. Duration of jaundice.—8 weeks. Degree of jaundice.—31.0. Blood fibrin.—487-536. Plasma fibrin.—650-800. No. of determinations.—3. Hæmorrhages four plus.

CASE VI.—Diagnosis.—Carcinoma of pancreas with obstructive jaundice. Male, forty-eight years old. Duration of jaundice.—6 months. Degree of jaundice.—15.0. Blood fibrin.—725. Plasma fibrin.—1150. No. of determinations.—1. No hæmorrhage.

CASE VII.—Diagnosis.—Carcinoma of pancreas with obstructive jaundice and cholelithiasis. Male, fifty-eight years old. Duration of jaundice.—10 weeks. Degree of jaundice.—12.0. Blood fibrin.—336. Plasma fibrin.—600. No. of determinations.—1. Hæmorrhage ten days later, just ante-mortem.

CASE VIII.—Diagnosis.—Carcinoma of pancreas with obstructive jaundice. Male, sixty-three years old. Duration of jaundice.—8 weeks. Degree of jaundice.—26.5. Blood fibrin.—420-612. Plasma fibrin.—600-800. No. of determinations.—4. Hæmorrhage four plus.

CASE IX.—Diagnosis.—Hepatitis with obstructive jaundice and cholelithiasis. Female, fifty years old. Duration of jaundice.—1 week. Degree of jaundice.—12.0. Blood fibrin.—310. Plasma fibrin.—500. No. of determinations.—1. No hæmorrhage.

CASE X.—Hepatitis with obstructive jaundice. Male, thirty years old. Duration of jaundice.—4 weeks. Degree of jaundice.—12.75. Blood fibrin.—341-558. Plasma fibrin.—550-900. No. of determinations.—5. Hæmorrhage three plus.

CASE XI.—Diagnosis.—Hepatitis with obstructive jaundice. Male, fifty-one years old. Duration of jaundice.—7 weeks. Degree of jaundice.—24.75. Blood fibrin.—330-612. Plasma fibrin.—550-900. No. of determinations.—10. Hæmorrhage two plus.

CASE XII.—Diagnosis.—Cirrhosis of liver with obstructive jaundice. Male, fifty-five years old. Duration of jaundice.—2 weeks. Degree of jaundice.—12.4. Blood fibrin.—270-384. Plasma fibrin.—450-600. No. of determinations.—3. No hæmorrhage.

CASE XIII.—Diagnosis.—Metastatic carcinoma of liver with obstructive jaundice. Male, sixty-two years old. Duration of jaundice.—8 weeks. Degree of jaundice.—26.0. Blood fibrin.—620. Plasma fibrin.—850. No. of determinations.—1. No hæmorrhage.

CASE XIV.—Diagnosis.—Cholelithiasis with obstructive jaundice. Female, forty-eight years old. Duration of jaundice.—1 week. Degree of jaundice.—20.8. Blood fibrin.—570-600. Plasma fibrin.—1000. No. of determinations.—2. No hæmorrhage.

CASE XV.—Diagnosis.—Carcinoma of the ampulla of Vater. Female, fifty-two years old. Duration of jaundice.—8 weeks. Degree of jaundice.—9.0. Blood fibrin.—324. Plasma fibrin.—600. No. of determinations.—1. Hæmorrhage four plus.

Blood fibrins are given in milligrams per 100 cubic centimetres of blood, and plasma fibrins in milligrams per 100 cubic centimetres of plasma. Normal values are, blood fibrin, 166 milligrams; plasma fibrin, 321 milligrams.

Repeated fibrin determinations were made both pre-operatively and post-operatively, when possible. A total of forty-one samples of blood were examined for blood and plasma fibrin values. In the entire group no diminution of the fibrin values was found, instead there was a marked increase in most cases. The minimum blood and plasma fibrins were 219 and 300 milligrams respectively. The maximum values were 1,046 milligrams and 1,275

BLOOD FIBRIN IN HÆMORRHAGE OF JAUNDICE

milligrams. The majority of the blood fibrins were in the neighborhood of 500 milligrams and the plasma fibrins lay between 600 and 800 milligrams. The mean values were 483 milligrams and 742 milligrams respectively. Compared with the mean normal values of 166 and 321 milligrams (*vide* Table I), the blood fibrin values in this group of cases with obstructive jaundice, are approximately three times as great, and the plasma fibrins are nearly two and one-half times the normal value.

Five of the cases which developed the typical hæmorrhagic diathesis of obstructive jaundice are of especial interest, as it was possible to study them

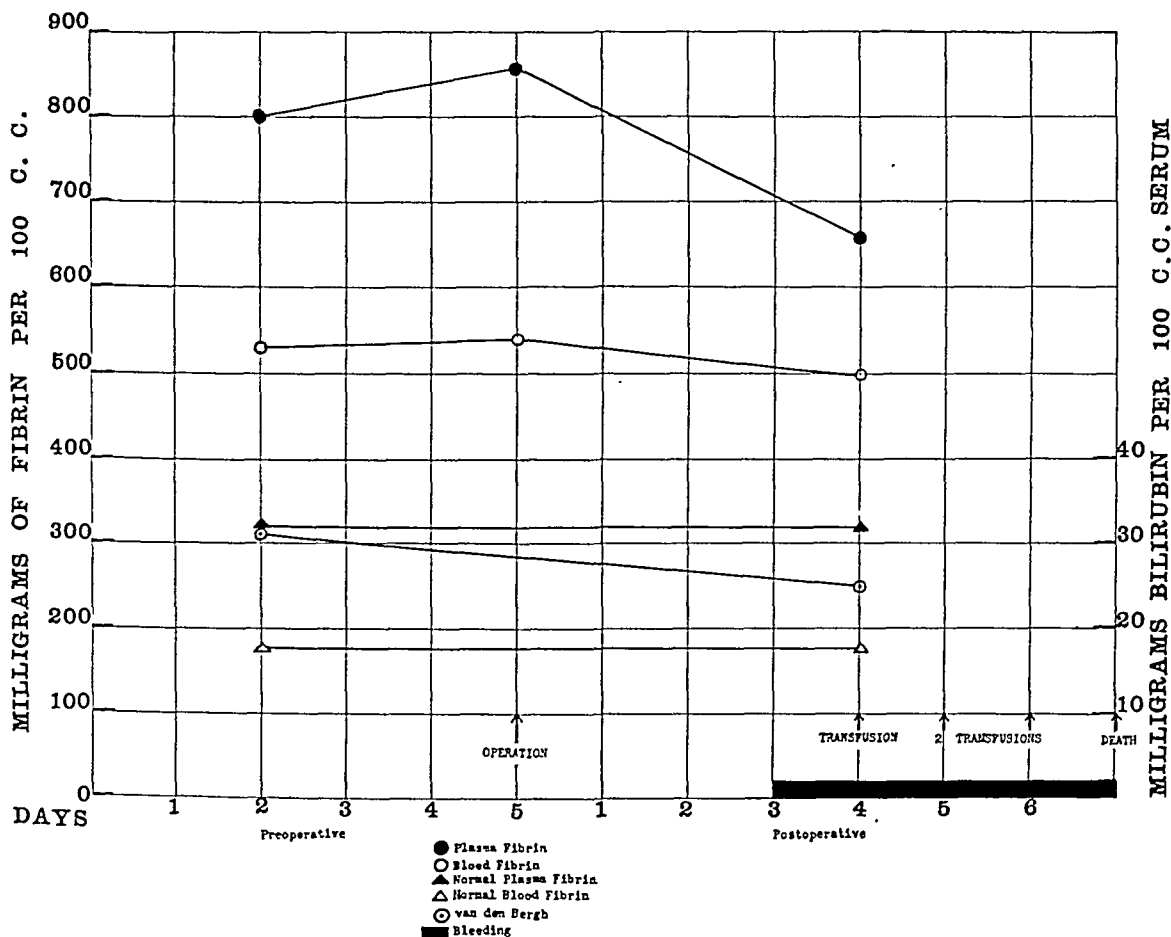


CHART I.—The blood and plasma levels in Case V.

before and during the bleeding stage. These were Cases III, V, VIII, X, and XI. (Table II.)

CASE REPORTS.—The following four cases with charts illustrate the high level of the blood fibrin which has been found in all these patients. I have chosen these four because they show the level before and during the actual bleeding.

(1) Case V, Chart I, shows the findings in a thirty-eight-year-old Irish workman, who entered the hospital complaining of jaundice of two months' duration without pain. He had a high degree of jaundice, 31 milligrams per 100 cubic centimetres of serum. The patient was placed on a high carbohydrate, low fat diet and was given three pre-operative injections of ten cubic centimetres of a 5 per cent. calcium chloride solution. At exploratory laparotomy under spinal anæsthesia a large distended gall-bladder was found with a small carcinoma of the pancreas occluding the common bile-duct. A cholecystogastrostomy was performed. Extreme care was taken to prevent hæmorrhage

at the suture line. A shoemaker's stitch was employed, using two needles and threads. This inner suture line was reinforced with a serosal stitch outside it. The abdomen was closed in layers without drainage. The patient stood the operation very well. Fluids were given post-operatively by clysis, vein and proctoclysis. Small amounts of water by mouth were started on the first day post-operative. On the third day post-operative he vomited 900 cubic centimetres of coffee-ground-like material. A nasal catheter was inserted and passed into the stomach. This was left in place as it continued to drain large amounts of bloody fluid. Within the next three days the patient received four whole blood transfusions, each one of 600 cubic centimetres. In spite of these, the bleeding continued, and death occurred on the seventh day following operation from uncontrollable hæmorrhage. Autopsy was not performed.

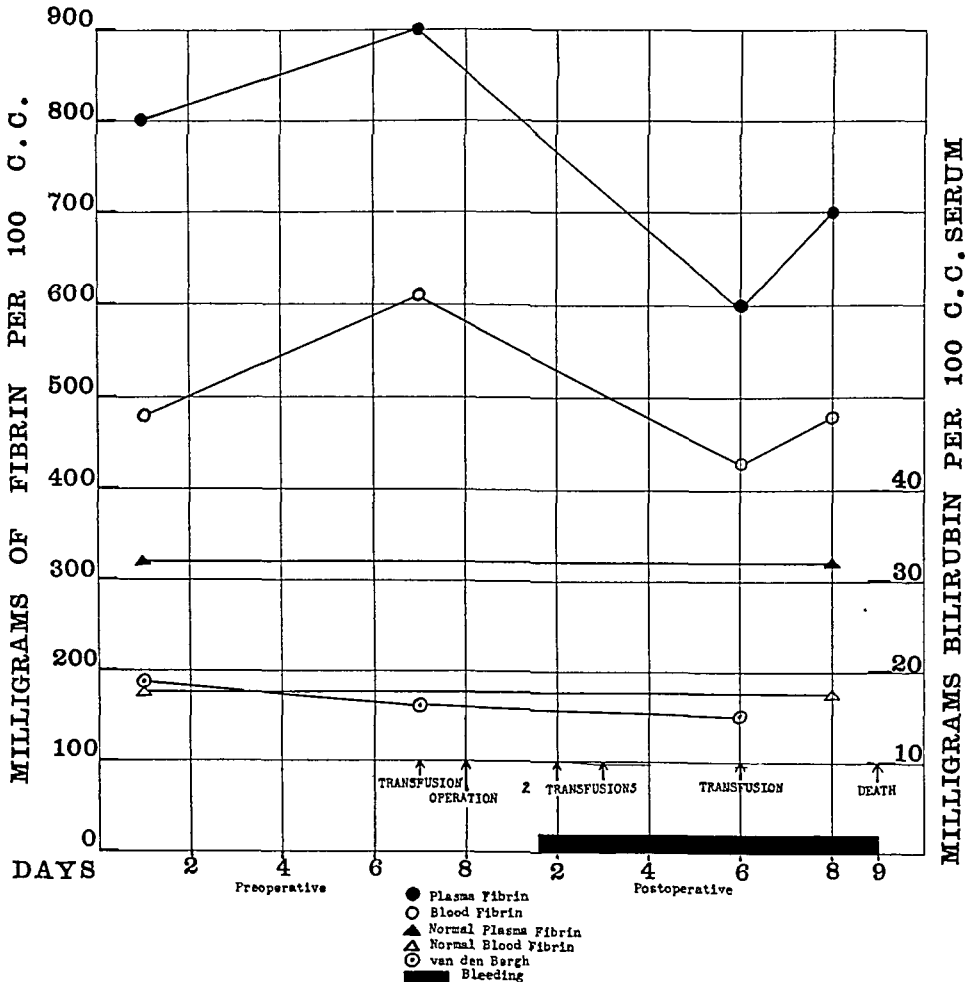


CHART II.—The blood and plasma levels in Case VIII.

Comment.—This patient died because of uncontrollable post-operative hæmorrhage and yet on three occasions, blood fibrin determinations showed no deficiency in the fibrin. The third estimation was done at the time bleeding was taking place, yet both the blood and plasma values are several times the normal values.

(2) Case VIII, Chart II shows the findings in a sixty-three-year-old man, who entered the hospital complaining of painless jaundice of eight weeks' duration, anorexia, nausea and general malaise. He had a high degree of jaundice with a serum bilirubin of 18.75 milligrams per 100 cubic centimetres of serum. A large distended gall-bladder and enlarged liver were palpable. After careful pre-operative preparation with fluids,

BLOOD FIBRIN IN HÆMORRHAGE OF JAUNDICE

glucose and blood transfusion, operation was performed. Under spinal anæsthesia a moderate-sized carcinoma of the head of the pancreas was found, which was obstructing the common bile-duct. The gall-bladder was filled with white bile. A cholecystogastrostomy was performed using three layers of chromic O catgut. The abdomen was closed in layers without drainage. Small amounts of water were given beginning the first day post-operative. The fluid intake was maintained by a continuous intravenous drip of 5 per cent. glucose solution in normal saline.

On the second day post-operative the patient vomited a little dark red bloody fluid and stomach lavage yielded 1,000 cubic centimetres of the same material. A nasal

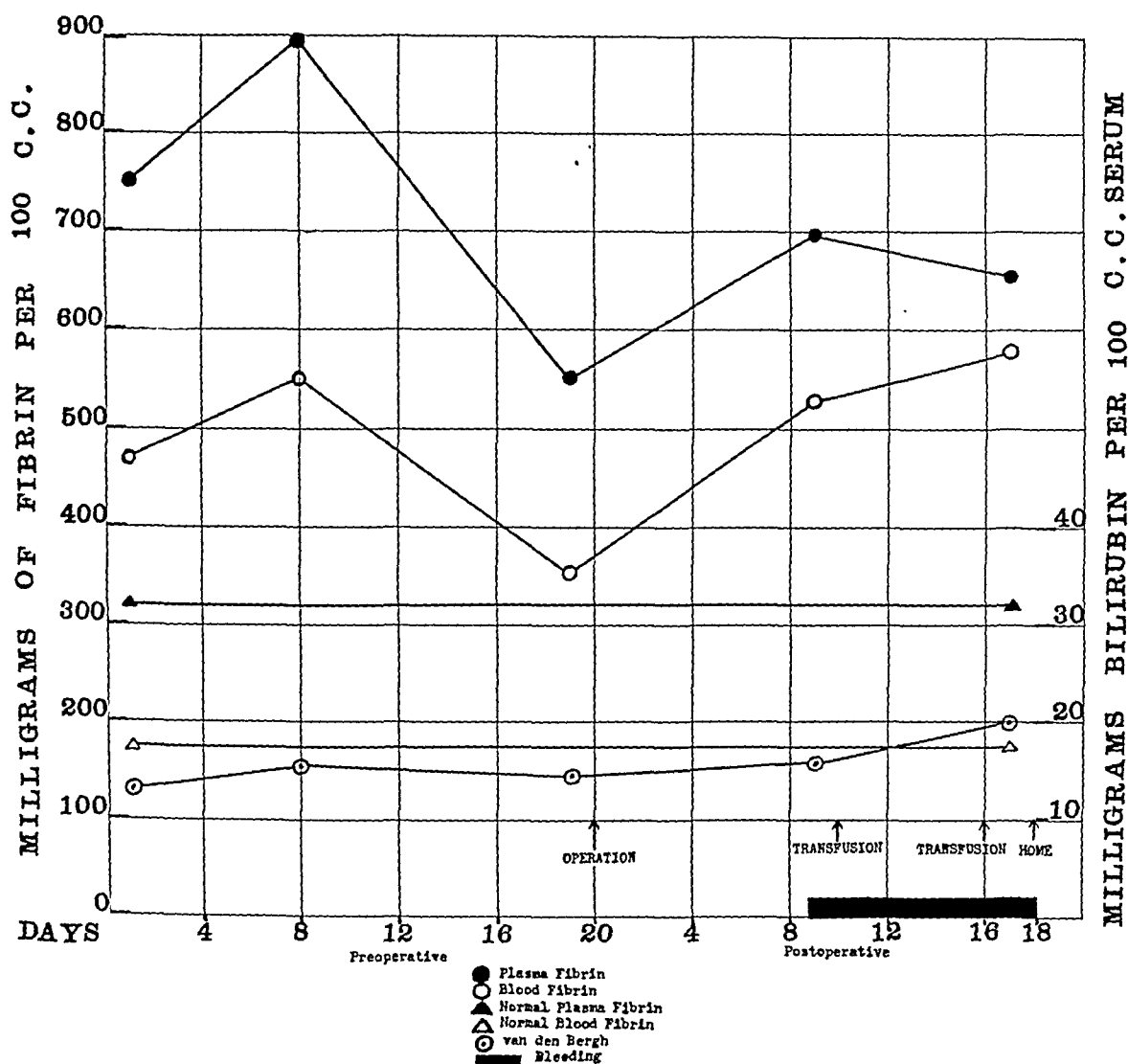


CHART III.—The blood and plasma levels in Case X.

catheter was passed into the stomach to drain off the fluid as it accumulated. Transfusions were given on the second, third, and sixth days post-operatively. The first two seemed to check the hæmorrhage temporarily, but the patient died on the ninth day post-operative from hæmorrhage and liver insufficiency. Bile was never demonstrated in the stomach contents. Autopsy confirmed the diagnosis, and in addition to the intra-biliary and gastro-intestinal hæmorrhage, there was considerable hæmorrhage around the cholecystogastrostomy with oozing into the peritoneal cavity.

Comment.—Blood and plasma fibrin determinations were done on four occasions, as the chart indicates. All of these are well above the normal value, even at the time hæmorrhage was taking place, thus showing that the hæmorrhage was not due to a lack of blood fibrin in this case.

(3) Case X, Chart III, shows the findings in a man of thirty years who entered the hospital because of painless, increasing jaundice of four weeks' duration. The serum bilirubin, according to the quantitative van den Bergh test, remained in the neighborhood of 13.0 milligrams. Stool examination on frequent occasions showed no bile. As a definite diagnosis could not be made, and because of persistent complete biliary obstruction, operation was advised. Exploratory laparotomy was performed under spinal anaesthesia three weeks after admission. No obstruction of the common bile-duct was found. A piece of liver was removed for biopsy which showed early biliary cirrhosis, thus accounting for the jaundice and clay-colored stools. Following

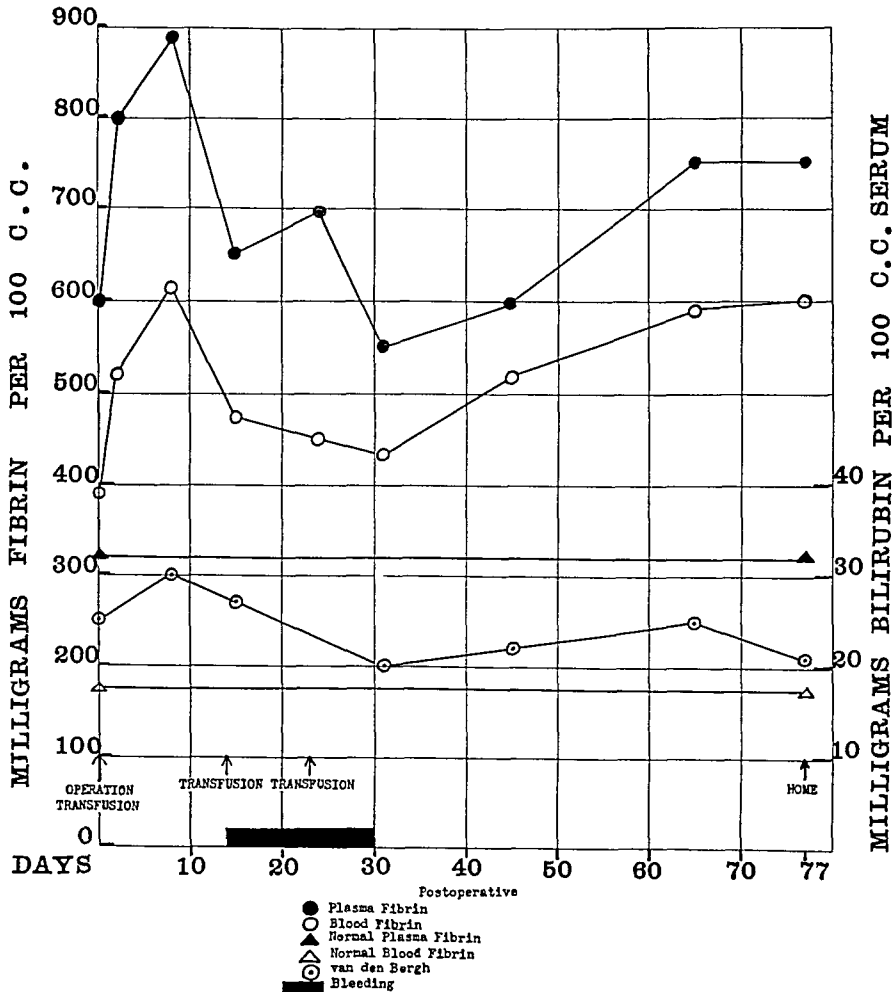


CHART IV.—The blood and plasma levels in Case XI.

the operation, the patient made a very slow recovery. The jaundice deepened considerably. On the ninth day post-operative, hæmorrhage from the wound was first noted. This became so alarming that two transfusions were given with partial control of the bleeding. The patient left the hospital the nineteenth day following operation, still bleeding from his wound. He died not long after leaving the hospital from hepatic insufficiency and cirrhosis of the liver.

Comment.—The obstruction of the biliary system in this case was not in the common bile-duct, but in the small biliary passages. The fibrin values, however, show much the same elevated level that the other cases of obstructive jaundice have shown. There was no diminution of them at the time of the post-operative bleeding.

(4) Case XI, Chart IV, shows the findings in a man of sixty-two years who

entered the hospital complaining of painless, increasing jaundice of seven weeks' duration. His stools were clay-colored and were bile negative. The jaundice was of severe intensity as the serum bilirubin was 25 milligrams according to the quantitative van den Bergh test. Exploratory laparotomy was done under ether anæsthesia. No obstruction of the common bile-duct was found. The liver was large and showed a moderate degree of cirrhosis. The patient's convalescence was uneventful until about the fourteenth day, when bleeding was noted from his wound. This was controlled by two transfusions of whole blood, but not until it had lasted about two weeks. The patient was kept in the hospital in all about eleven weeks. His jaundice persisted. Continuous intravenous administrations of 5 per cent. glucose in normal saline was used, which I feel prolonged his life. He had no more actual bleeding, although he developed a number of areas of ecchymosis on his right arm. These were noted about fifty-three days following operation, and remained about a week. These, along with a very rapid sedimentation rate, still indicated a definite hæmorrhagic diathesis. He was eventually discharged from the hospital and died about six months later from cirrhosis of the liver with complete biliary obstruction.

Comment.—This case is similar to the preceding one. On all occasions the fibrin was found to be greatly elevated. The highest point was reached immediately post-operatively, but it was still markedly elevated during the bleeding stage and also when he developed the ecchymotic areas on his arm. At no time in his long stay in the hospital was there any evidence of a fibrin deficiency.

Discussion.—The hæmorrhagic diathesis of obstructive jaundice has not as yet been satisfactorily explained. In studying the possible causes of this serious complication, it seemed possible that a lack of fibrin in the blood might be an important factor, since in severe liver destruction there exists a marked diminution of the blood fibrin and an associated hæmorrhagic diathesis. Accordingly, blood fibrin studies were carried out on a series of fifteen patients with obstructive jaundice. These cases were selected because they all had a high degree of obstructive jaundice. Seven of this group, or 46.7 per cent., developed post-operative hæmorrhage. In three of these, or 20 per cent. of the entire group, hæmorrhage played a major rôle in the cause of death.

Repeated fibrin determinations were made according to the modification of the Foster and Whipple method described by Schultz, *et al.*¹⁰ Forty-one determinations were made in this series of cases. The blood fibrins varied from 219 to 1,046 milligrams per 100 cubic centimetres of blood and the plasma fibrins from 300 to 1,275 milligrams per 100 cubic centimetres of plasma. The mean blood and plasma fibrin values were respectively 483 milligrams per 100 cubic centimetres of blood and 742 milligrams per 100 cubic centimetres of plasma. In Case II on one occasion the blood fibrin was 1,046 milligrams. This high value was probably due to the fact that the patient had a diffuse broncho-pneumonia at the time the estimation was made. No case showed a fibrin value below normal. Compared to the mean normal fibrin values the mean blood and plasma fibrin values in this group of cases are respectively three, and two and one-half times as great.

Fibrin determinations were made pre-operatively and post-operatively. Immediately following operation there was a transient rise in the fibrin level in a few of the cases. This temporary rise was probably due to operative

wounds and low-grade pulmonary infections, as both these conditions have been shown experimentally in dogs to increase the fibrin level.¹⁰ In the majority of cases the fibrin level remained elevated. There was no noticeable diminution of it, even up to the time of the patient's death.

Of especial interest were the seven cases which developed post-operative bleeding. In five of these, determinations were made before and during the actual bleeding. Comparison of the fibrin levels before and during the bleeding, (see Table III) show that there was a slight decrease of the latter in four of these cases. In the fifth case the average fibrin value was higher during the bleeding. After the hæmorrhage stopped in this case the fibrin level dropped even lower than before its occurrence. These variations before, during, and after hæmorrhage are probably of little significance. The important fact, however, is that during the bleeding stage there was no marked decrease in the fibrin level, and that in all cases the amount of fibrin was two to three times the normal value.

TABLE III
Fibrin Values in Cases with Bleeding

Case	Before Hæmorrhage		During Hæmorrhage		After Hæmorrhage	
	Blood Fibrin	Plasma Fibrin	Blood Fibrin	Plasma Fibrin	Blood Fibrin	Plasma Fibrin
3	568	800	487	650	—	—
5	531	825	487	650	—	—
8	546	850	450	650	—	—
10	457	733	447	675	—	—
11	384	600	461	675	375	575

Blood fibrins are given in milligrams per 100 cubic centimetres of blood, and plasma fibrins in milligrams per 100 cubic centimetres of plasma. Normal values are, blood fibrin, 166 milligrams; plasma fibrin, 321 milligrams.

CONCLUSIONS

(1) Fifteen patients with obstructive jaundice were found to have blood and plasma fibrin levels several times the normal value.

(2) In six patients who developed post-operative bleeding the fibrin levels were several times the normal values even at the time of actual bleeding.

(3) In obstructive jaundice, there is apparently no deficiency in the blood fibrin.

(4) The hæmorrhagic diathesis of obstructive jaundice is not explainable by a quantitative deficiency of the blood or plasma fibrin.

BIBLIOGRAPHY

- ¹ Zimmerman, L. M.: The Effect of Parathyroid Hormone on Blood Coagulability. Amer. J. Med. Sci., vol. clxxiv, p. 379, 1927.
- ² Linton, R. R.: The Relation of Calcium to the Hæmorrhagic Tendency in Obstructive Jaundice. ANNALS OF SURGERY, vol. xciii, p. 707, 1931.
- ³ Petré, G.: Ueber die post-operativen lethal verlaufenden sog. cholämischen Blutungen. Bruns. Beitr., vol. cx, p. 237, 1918.
- ⁴ *Idem*: Untersuchungen ueber die Blutgerinnung bei Ikertus. Bruns. Beitr., vol. cxx, p. 501, 1920.

BLOOD FIBRIN IN HÆMORRHAGE OF JAUNDICE

- ⁵ Foster, D. P., and Whipple, G. H.: Blood Fibrin Studies; an Accurate Method of Quantitative Analysis of Blood Fibrin in Small Amounts of Blood. *Am. J. Physiol.*, vol. lviii, p. 365, 1922.
- ⁶ Corin, G., and Ansiaux, G.: Untersuchung Uber Phosphorvergiftung. *Vrtljschr. f. gerichtl. Med.*, 3f vii, vol. lxxx, p. 122, 1894.
- ⁷ Doyon, M.: Incoagulabilité du Sang Provoquée par le Chloroforme. *Rôle du Foie. Compt. rend. Soc. d. Biol.*, vol. lviii, p. 30, 1905.
- ⁸ Whipple, G. H., and Hurwitz, S. H.: Fibrinogen of the Blood as Influenced by the Liver Necrosis of Chloroform Poisoning. *Jour. Exp. Med.*, vol. xiii, p. 136, 1911.
- ⁹ Foster, D. P., and Whipple, G. H.: Blood Fibrin Studies. *Amer. Jour. Physiol.*, vol. lviii, p. 379, 1922.
- ¹⁰ Schultz, E. W., Nichols, J. K., and Schaefer, J. H.: Studies on Blood Fibrin. *Amer. Jour. Path.*, vol. i, p. 101, 1925.
- ¹¹ Rous, P., and Larimore, L. D.: Biliary Factor in Liver Lesions. *Jour. Exp. Med.*, vol. xxxii, p. 249, 1920.
- ¹² Snell, A. M., Greene, C. H., and Rowntree, L. G.: Diseases of the Liver; Further Studies in Obstructive Jaundice. *Arch. Int., Med.*, vol. xl, p. 471, 1927.
- ¹³ Gram, H. C.: Fibrin Percentage in Blood. *Acta. Med. Scandinav.*, vol. lvi, p. 107, 1922. (In English.)
- ¹⁴ Foster, D. P.: A Clinical Study of Blood Fibrin. *Arch. Int. Med.*, vol. xxxiv, p. 301, 1924.
- ¹⁵ McLester, J. S.: Diagnostic Value of Blood Fibrin Determination with Special Reference to Disease of the Liver. *Jour. Am. Med. Assoc.*, vol. lxxix, p. 17, 1922.
- ¹⁶ McLester, J. S., *et al.*: Blood Fibrin Studies in Various Diseases with Special Reference to Disease of the Liver. *Arch. Int. Med.*, vol. xxxv, p. 177, 1925.
- ¹⁷ Howe, P. E.: The Determination of Fibrinogen by Precipitation with Sodium Sulfate Compared with the Precipitation of Fibrin by the Addition of Calcium Chloride. *Jour. Biol. Chem.*, vol. lvii, p. 235, 1923.
- ¹⁸ Jacoby, M.: Ueber die Beziehungen der Leber und Blutveränderungen bei Phosphorvergiftung zur Autolyse. *Ztschr. f. Physiol. Chem.*, vol. xxx, p. 174, 1900.
- ¹⁹ Melchior, E.: Zur Theorie der Cholämischen Blutungen. *Beiträge zur Klin. Chir.*, vol. cxxxix, p. 162, 1927.
- ²⁰ Baumann, J.: Zur Frage eines Zusammenhange zwischen Leberschädigung, und Fibrinogengehalt des Blutes. *Deutsch. Zeitsch. für Chir.*, vol. ccxxii, p. 212, 1930.
- ²¹ Weltmann, O., and Neumayer, K.: Das Fibrinogen in Diagnostischen Kalkul der Leberkrankheiten. *Medizinische Klinik*, vol. xxi, p. 629, 1925.
- ²² Wildegans, H.: Experimentelle und Klinische Untersuchungen bei Cholämie. *Arch. f. Klin. Chir.*, vol. cxlii, p. 698, 1926.
- ²³ Murakami, J., and Yamaguchi, T.: Fibrinogen and Fibrin Ferment Content of the Blood in Intestinal Disease. *Ann. de Méd.*, vol. xv, p. 297, 1924.
- ²⁴ Isaac-Krieger, K., and Hiege, A.: Der Fibrinogengehalt des Blutes bei Leberkrankungen. *Klin. Wchschr.*, vol. ii, p. 1067, 1923.
- ²⁵ Schultz, W., and Scheffer, W.: Ueber Ikterus, Hæmorrhagien und Blutkoagulation. *Berl. Klin. Wchschr.*, vol. lviii, p. 789, 1921.
- ²⁶ Wohlgemuth, J.: Eine neue Methode zur quantitativen Bestimmung des Fibrin-ferment und Des Fibrinogen in Körperflüssigkeiten und in Organen. *Biochem. Zeitschr.*, vol. xxv, p. 79, 1910.

THE SURGICAL TREATMENT OF ACUTE CHOLECYSTITIS

BY MAX M. ZINNINGER, M.D.

OF CINCINNATI, OHIO

FROM THE DEPARTMENT OF SURGERY OF THE UNIVERSITY OF CINCINNATI, AND THE CINCINNATI GENERAL HOSPITAL

THE importance of early operation in acute appendicitis has been so definitely established, and has been commented upon so frequently, that it has been generally accepted by members of the medical profession. In the case of acute inflammation of the gall-bladder, there seems to be no such unanimity of opinion. Very frequently, unless the attack is fulminant, the physician counsels delay in this condition, hoping that by time-honored conservative treatment, operation may be postponed until an interval, or avoided indefinitely. While it is well known that such a policy is frequently attended by success, we are convinced that it has been insufficiently emphasized that in many instances the inflammatory process either fails to subside, or becomes more intense, leading to serious pathological lesions, complications, increased distress to the patient, prolonged convalescence, and even death. Let us make it clear that we are not considering cases of acute gall-bladder colic such as occur in the course of a chronic cholelithiasis, but only acute inflammatory lesions of the gall-bladder. The usual symptoms and signs of such a condition are pain in the abdomen, nausea, vomiting, fever, leucocytosis, and tenderness over the gall-bladder, usually associated with muscle spasm or rigidity. A distended gall-bladder may often be palpated provided the muscle response is not too intense. A slight but definite jaundice is not infrequent, due usually to associated cholangiitis. Pathologically, there is found a distended gall-bladder, surrounded by fibrinous adhesions, the wall red and œdematous. The cystic duct is usually occluded by adhesions, by inflammatory œdema, or by an impacted stone. As the disease progresses, the viscus may become filled with a hæmorrhagic or purulent exudate, and subsequently there may develop gangrene or perforation of the wall.

Given a patient with such a condition, what treatment should be instituted—watchful waiting or early surgical interference? To answer this question satisfactorily, there are several things we should know. First, what is the likelihood that the attack will subside; second, what are the chances that the attack will fail to subside or will become worse; third, what will be the ultimate outcome if the attack does subside spontaneously; and fourth, are there any advantages of early as compared with late operation? As regards the first question, it is generally agreed that many of the milder cases subside quickly and spontaneously, but as far as I am aware there are no available figures on which to estimate the percentage that may be expected to do so. Likewise in regard to the third question—namely, the incidence of subsequent trouble—there are no reported figures. I am convinced, however, that a large proportion of those who have had an acute inflammatory

lesion of the gall-bladder which subsided, will have subsequent and recurrent disability finally leading to operation. As regards the second and fourth questions, there is some small but suggestive statistical evidence. In an attempt to answer these questions we have recently reviewed the records of eighty-nine patients admitted to the Cincinnati General Hospital during the years 1925-1930, inclusive, in whom a diagnosis of acute cholecystic disease was made and who subsequently were operated upon. In this group there were seventy females and nineteen males. The age incidence is shown in Table I.

TABLE I

	<i>Age</i>					
	<i>Less Than 20</i>	<i>20-29</i>	<i>30-39</i>	<i>40-49</i>	<i>50-59</i>	<i>60+</i>
No. of patients.....	2	14	17	29	14	11

The average temperature was 100.2° F.; average pulse, 98; average leucocyte count, 15,766. The highest temperature was 103.4° F.; highest pulse, 120; highest leucocyte count, 31,000. The lowest temperature was 97° F.; lowest pulse, 60; and lowest leucocyte count, 6,500. There was found a close correlation between the leucocyte count and the severity of the clinical and pathological condition. In all the cases with empyæma of the gall-bladder, the leucocyte count was more than 15,000. The duration of symptoms before admission was less than twenty-four hours in twenty-one cases, one day to one week in twenty-four cases, and more than one week in forty-four cases.

Thirty-five of these patients were operated upon immediately after admission. In this group, the shortest duration was three hours, the longest ten days, the average three days. When these cases were analyzed according to the duration of the attack, the following observations were made:

TABLE II

35 Cases Operated upon Immediately after Admission

	<i>Duration of Attack</i>		
	<i>Less Than 48 Hours</i>	<i>2-5 Days</i>	<i>More Than 5 Days</i>
Number of cases.....	12	15	8
Average number of days in hospital.....	22.1	24.1	24.7
Deaths.....	0	1	2
Mortality, per cent.....	0	6.6%	25%
Pathological findings	Simple acute cholecystitis..	11	5
	Uncomplicated empyæma..	0	9
	Empyæma with abscess...	0	0
	Empyæma with gangrene..	1	1
	Empyæma with rupture...	0	0

These patients were all definitely ill at the time of admission, so ill that there seemed to be no justification for delaying operation. The gall-bladder was removed in twenty-eight cases, drained in seven cases. Of the three that died, one had a cholecystectomy and two a drainage operation. In all

those that died there was empyæma complicated by gangrene of the wall of the bladder or the formation of abscess outside of it. One death occurred thirteen hours after operation from coronary sclerosis, one on the fifth day from bronchopneumonia, and one on the fourteenth day with an intra-abdominal abscess and a pancreatic abscess obstructing the common duct. The total mortality was 3 in 35, or 8.5 per cent.

The remaining fifty-four patients were observed for a period of twenty-four hours to twelve days after admission and before operation. This delay was made either because the patient refused operation or because it was the opinion of the attending or resident staff that the attack was comparatively mild and might subside. In this group of fifty-four patients, analysis shows that twenty, or 37.7 per cent., improved, the attack subsided, and they were subsequently operated upon in an interval; nineteen, or 35.1 per cent., failed to change significantly and at the time of operation were in essentially the same status as at the time of admission; fifteen, or 27.7 per cent., became definitely worse while under observation and suitable expectant treatment. In this last group four had a perforation of the gall-bladder at the time of operation and certainly in three instances the perforation occurred while the patients were on the wards. It is seen that of the fifty-four patients, in thirty-four, or 62.9 per cent., the attack either failed to subside or became worse.

An attempt was made to discover the reason why the attack failed to subside in these thirty-four instances. This could not be determined very satisfactorily, the only available data being the findings at operation, plus the investigation of the pathological specimen in the laboratory. It was found that in the cases that did not subside, there was generally a serious infection of the gall-bladder associated usually with an obstruction of the cystic duct. In the instances in which the attack subsided, less marked pathological change existed at the time of operation than in those in which there was failure to subside. No definite finding was made, however, which would enable us to predict in the future which cases would be likely to subside, and which become worse. Tabulation of the pathological findings at operation is presented in Table III.

TABLE III

Operative Findings in 54 Cases Treated Expectantly for One to Twelve Days Before Operation

<i>Clinical Course During Observation</i>	<i>Total Cases</i>	<i>Chronic Cholecys- titis</i>	<i>Acute Cholecys- titis</i>	<i>Uncom- plicated Empy- æma</i>	<i>Abscess Outside</i>		
					<i>Gall-bladder No Perfor- ation Dem- onstrated</i>	<i>Empy- æma with Gangrene</i>	<i>Empy- æma with Rupture</i>
Improvement...	20	13	4	1	1	0	1
No change.....	19	0	13	5	1	0	0
Worse.....	15	0	3	6	0	2	4

It can be seen that of the twenty cases that showed clinical improvement, thirteen showed only chronic lesions at operation, *i.e.*, the attack had un-

ACUTE CHOLECYSTITIS

questionably subsided. Of the nineteen who showed no significant change in their clinical condition, thirteen showed simple acute inflammation, and six showed more serious lesions—empyæma and abscess formation. Of the fifteen who clinically became worse, only three showed uncomplicated acute changes, the rest serious pathological lesions—empyæma, gangrene and rupture. As was previously mentioned, this does not demonstrate the cause of failure of an attack to subside, but does show that it is the serious inflammatory lesions which are most prone to persist. Since empyæma of the gall-bladder was found almost exclusively in cases that failed to show clinical improvement, it is presumptive evidence that once this condition has developed it will persist in the majority of cases until relief is obtained by operative interference. In this connection it is apropos to reëmphasize the important correlation between the leucocyte count and the serious inflammatory lesions of the gall-bladder. In this series, the leucocyte count was above 15,000 in every case of empyæma of the gall-bladder.

Since in only two of these patients was the duration of the disease less than two days, they have been divided according to whether the attack had lasted less than one week or more than one week. Using this criterion, the following findings were made:

TABLE IV

	<i>Total Duration of Attack Before Operation</i>	
	<i>Less Than One Week</i>	<i>More Than One Week</i>
Number of cases.....	18	36
Average days in hospital—post-operative.....	25.2	27.2
Deaths.....	1	3
Mortality, per cent.....	5.5%	8.33%
Pathological findings	Chronic cholecystitis.....	4
	Acute cholecystitis.....	10
	Uncomplicated empyæma...	4
	Gangrene.....	0
	Rupture.....	0
		11 (2 with abscess)
		10
		8
		2
		5

The total mortality in the eighty-nine cases was seven cases, or 7.8 per cent. Three of the deaths occurred among the forty-five cases whose attack had lasted less than one week (mortality 6.66 per cent.), and four of them in the forty-four cases in which the attack lasted more than one week (mortality 9 per cent). In considering mortality in relation to duration of the attack, it is interesting to note that Miller,³ in 1930, found that in 200 cases of acute gall-bladder treated at the Massachusetts General Hospital, the average duration of the attack in twenty-seven fatal cases was fifteen days, while in 173 who recovered the average duration was 8.3 days. Table V shows the relationship between the mortality and the pathological lesion in our series of eighty-nine cases, all of whom had an admission diagnosis of acute cholecystitis.

TABLE V

Mortality in 89 Cases in Relation to Pathological Lesion

	<i>Total Cases</i>	<i>Deaths</i>	<i>Mortality, %</i>
Chronic cholecystitis.....	15	1	6.6
Simple acute cholecystitis.....	36	2	5.5
Uncomplicated empyæma.....	22	1	4.5
Empyæma with gangrene or rupture.....	16	3	18.7

This shows the sharp rise in the mortality in association with gangrene and rupture of the gall-bladder, and is in agreement with the published findings of others. For example, Alexander¹ reported twenty cases of rupture of the gall-bladder with a mortality of 50 per cent. in those with acute free perforation, and a mortality of 25 per cent. with subacute or walled-off perforation.

The data presented have shown that delay in operating in certain cases of acute cholecystitis influences unfavorably the development of serious complications, and as these develop the mortality rises. It is possible to present evidence of additional advantages of early operation. For this purpose we present here in Table VI the findings of H. F. Graham² of 198 cases of acute cholecystitis from the Methodist Hospital of Brooklyn, N. Y.

TABLE VI

198 Cases of Acute Cholecystitis Reported by Graham

	<i>Duration of Attack Before Operation</i>	
	<i>Less Than 48 Hours</i>	<i>More Than 48 Hours</i>
Total number of cases.....	20	178
Mortality.....	5%	6.2%
Average days in hospital.....	19.5	26.4
Average number of dressings.....	4½	10½
Incidence of post-operative complications...	5%	18%

These statistical reports of fairly large groups of patients answer, we believe, questions two and four postulated earlier in this paper. They show that in a majority of patients admitted to a general city hospital with acute inflammatory lesions of the gall-bladder the attack failed to subside under suitable conservative treatment. It has also been shown that early operation reduces the hospital stay, shortens the convalescence, probably reduces the number of dressings, the incidence of complications and the mortality. These, we believe, are the advantages to be expected of early operation.

One important point about which no statistical data can be collected is the technical difference between cholecystectomy done in the acute stage and in the interval. Each of the ten surgeons who operated on the eighty-nine patients in our report is of the opinion that the operation of cholecystectomy is more easily performed, as a rule, in the acute stage than in an interval. During the acute stage it is often surprising how easily the adhesions surrounding the gall-bladder and ducts can be separated, and the gall-bladder freed from the liver. On the other hand, after the attack has subsided, the adhesions formed during the attack become more and more fibrous and ad-

herent. During the acute stage, old adhesions seem to become less firmly attached, possibly due to increased vascularity and oedema. At any rate, it is rare to find an acutely inflamed gall-bladder which is as difficult to free as the average chronically inflamed one. The incidence of post-operative wound infection is probably somewhat greater in patients operated upon during the acute stage, but in our experience such infection has not been severe nor led to serious consequences, and it is our opinion that this aspect can be disregarded. We have also found that it is usually possible to remove the gall-bladder except in the very late cases with extremely ill patients, or those with massive adhesions, localized abscess, *etc.* In our series, the gall-bladder was removed in seventy-seven cases with five deaths, a mortality of 6.5 per cent.; drainage was done in twelve instances with two deaths, a mortality of 16.6 per cent. The higher mortality in the cases with drainage was undoubtedly due to the more serious condition of the patients.

The above presentation has made it clear that we advocate early operation in acute cholecystitis. We do not believe, however, that immediate operation should be recommended as a routine in all cases as soon as the diagnosis is made. We try to judge each case on its individual merits, realizing that the longer an attack persists the more dangerous is the condition likely to become. If the attack is fulminant from the start, if it fails to subside promptly, or if it increases in intensity while under observation, early operation is indicated and offers definite advantages.

SUMMARY

Eighty-nine cases of acute-gall-bladder disease are reviewed. These have been divided into two groups, one of thirty-five cases operated upon immediately after admission, and another of fifty-four cases observed from one to twelve days before operation. In the group held under observation, only twenty, or 37.7 per cent., showed improvement, and in these subacute or chronic inflammation was found at operation. Nineteen, or 35.1 per cent., showed no significant change in signs or symptoms during the period of observation, and in them uncomplicated acute cholecystitis and empyæma were the lesions most frequently found at operation. Fifteen, or 27.7 per cent., became definitely worse while under observation, and in them empyæma, gangrene and rupture of the gall-bladder were found. The total number of cases in the second group which failed to subside was, therefore, thirty-four, or 62.9 per cent. The average leucocyte count was 15,766 for the entire series. In all cases of empyæma it was above 15,000. The incidence of serious pathological lesions and the mortality were found to rise with the duration of the attack. With early operation the hospital stay and the mortality were less than with late operation.

CONCLUSIONS

In acute inflammatory gall-bladder disease, a high percentage of cases fails to improve under conservative, *i.e.*, non-operative treatment.

Emphyæma of the gall-bladder is usually associated with a high leucocyte count (15,000 or higher), while the fever may be very variable.

When emphyæma of the gall-bladder once develops it is unlikely to subside spontaneously and may progress to gangrene and rupture of the wall. When these complications occur, the mortality rate rises rapidly.

It is, therefore, recommended that in acute infections of the gall-bladder immediate operation be performed if the symptoms are severe and particularly if there is associated high leucocytosis. Early operation is also indicated if the attack fails to subside promptly.

BIBLIOGRAPHY

- ¹ Alexander, E. G.: Acute Perforation or Rupture of the Gall-Bladder. *ANNALS OF SURGERY*, vol. lxxxvi, p. 765, 1927.
- ² Graham, H. F.: The Value of Early Operation for Acute Cholecystitis. *ANNALS OF SURGERY*, vol. xciii, p. 1152, 1931.
- ³ Miller, R. H.: Acute Cholecystitis. *ANNALS OF SURGERY*, vol. xcii, p. 644, 1930.

INTRAMURAL CALCIFICATION OF THE GALL-BLADDER

BY JAMES E. DAVIS, M.D.

AND

R. H. BOOKMYER, M.D.

OF DETROIT, MICH.

A MULTIPLE number of causes have been assigned for intramural calcification of the gall-bladder. The most important of those listed are the following:

(a) Ulcerative cholecystitis with inflammatory exudate production causing obstruction of the lymphatics and of bile passing through the cystic duct.

(b) A second view is given that the calcareous processes result from phlegmonous exudate forming abscesses in the wall (Aschoff, Kerr, Flörchen¹).

(c) Intramural formation of stones in his ducts may result in an extension of the process to the wall (Aschoff¹).

(d) Extravasation of blood-cells and hæmorrhage in the gall-bladder wall may mobilize calcium salts irregularly within the wall (Davis²).

(e) Calcification may be due to cholelithic catarrh and inflammatory products of long duration (Mayo Robson,³ Rolleston,⁴ Delafield and Prudden⁵).

(f) Extreme resorption of bone may result in widespread deposits of calcareous salts, particularly in the gall-bladder (Adami⁶).

(g) Calcification generally occurs in vascular disorders of tissues. Local necrosis or fibrosis antedates intercellular calcification (Stengel and Fox,⁷ MacCallum⁸).

(h) Calcium is deposited in the gall-bladder as a result of long-continued irritation (Moynihan⁹).

The infrequency of occurrence of intramural calcification of the gall-bladder wall is confirmed by literature and communications recently received from authors who have reported studies of a series of gall-bladders by X-ray and surgical means. In nine well-known text-books of surgery or pathology the process is not mentioned. In 8,695 cases of gall-bladder pathology reported by nine writers, calcification of the wall is not recorded.

Flörchen¹ quotes two cases reported by Bitzengiger in a series of 1,200 gall-bladder operations. In both of these cases the history was described as typically characteristic of cholangitis, being of short duration with elevation of temperature.

In one case a large gall-bladder ten centimetres by four centimetres with stony or button firmness like porcelain was found. The serosa was white and definitely separated from the other layers. No mucous membrane was present. The calcareous deposits were in the muscular and submucosal coats, particularly marked in the layers of the muscularis. In the cavity there was a cholesterin stone. A secondary finding of cancer of the stomach was noted. The clinical symptoms in the two cases were so unimportant as to hardly indicate operative procedures.

Baless and Skinner¹⁰ have reported one case, a woman fifty-two years of age, who had not been ill for twenty-seven years. Her symptoms, lasting for two days, were at first suggestive of appendicitis, later changing to those of gall-bladder disease. The X-ray showed calcification of the bladder wall and a calculus formation. The lumen was filled with thick bile.

Holden¹¹ has reported one case, a woman of fifty-two years of age, who had a history of severe pain thirty years prior to gastric distress and gas formation. The X-ray showed a circular shadow under the surface of the liver. At operation the gall-bladder was found to be brittle and generally calcified and there was a stone within the lumen. There was also chronic ulcerative cholecystitis present.

Moore¹² reported two examples of intramural calcification in old patients who were not submitted to operation (hence the cases were not unequivocally established). The X-rays of these patients were published in *Diseases of the Gall Bladder and Bile Ducts*, by Graham, Cole, Copher and Moore; Lea and Febiger, Philadelphia, 1928.

Kirklin¹³ reports under date of November 3, 1931, that during the past seven years at The Mayo Clinic they were able to find only four cases of intramural calcification of the gall-bladder that had been rayed and proved at operation to have had definite intramural calcification. The total number of gall-bladder operations during this period was 5,826.

CASE I.—Woman; aged fifty-eight years. Providence Hospital, No. 1749-N. Chief complaints, indigestion, nausea, sour stomach, vomiting, and pain in right upper quadrant. A history that during childhood she had measles, and at sixteen years had inflammatory rheumatism which confined her to bed for three months. The present illness began about five years ago with stomach sickness unaccompanied by pain; this sickness continued at intervals for three years; there was no distress after taking food, but water seemed to aggravate the stomach sickness.

During the last two years pain developed, occurring in attacks; there was radiation of this pain over the entire shoulder and frequently to the back and left side, passing upward between the scapulæ. Nausea and vomiting occurred often and at most any hour, and were followed by sour taste in the mouth and emesis of a yellowish material. During the past few years there had been much belching of gas and a loss of several pounds in weight. About a year ago there was an attack of pain and distress lasting three weeks. Vomiting and resting in the prone position gave relief from this pain, but standing aggravated the pain.

Father died at seventy-four years from Bright's disease.

Mother died at sixty-nine years from carcinoma of stomach.

One brother and four sisters are living and well.

Menstrual History.—Negative. Menopause occurred six years ago.

Examination was essentially negative, except for the following: Nasal septum was deviated to the right. All teeth had been removed from the mouth. Tonsils were atrophied. Mucous membranes of the mouth showed some pallor. Tongue was slightly coated and showed some tremor when protruded. Heart was enlarged several centimetres to the left and gave a blowing systolic murmur at the apex; but could be heard in the other three areas. Blood-pressure was 120/75.

Abdomen was slightly enlarged and there was a questionable tumor in the upper abdomen in the mid-line. The liver border was palpable two to three centimetres below the right costal margin. There was some tenderness over the pyloric area of the stomach.

Laboratory Examination.—Urine: specific gravity, 1.010, trace of albumin, trace of sugar.

Blood: hemoglobin, 70 per cent.; red blood-cells, 3,800,000; white blood-cells, 5,300.

At operation the gall-bladder was found surrounded by numerous adhesions; the fundal portion ruptured during removal and considerable milky fluid escaped into the abdominal cavity.

The removed gall-bladder (Fig. 1) contained in its neck an oval-shaped stone, which measured four centimetres in length and three centimetres in cross diameter; the stone

INTRAMURAL GALL-BLADDER

was slightly encrusted and adhered slightly to the bladder wall. The bladder wall was stiffened and had a fragile character with deposition of inorganic material in all layers of the wall. Palpation gave the sensation of eggshell resistance and at one place there was fracturing of the wall. The wall had a thickness of seven millimetres, and where it surrounded the stone, three millimetres.

Microscopical Examination.—The mucosal portion of the wall had been completely destroyed; the muscularis was intact only in certain areas; in these areas the muscle bundles showed atrophy with the cell nuclei almost completely obliterated; the fibrous layer was narrower than normal and its cells exhibited advanced atrophy with extensive loss of cell nuclei; the blood-vessels were sclerotic, the intimal layer being particularly thickened, so as to almost close the lumina; the muscle cell nuclei were better preserved than were those in the muscularis or fibrous layers.

Distributed extensively through other portions of the wall there were areas of

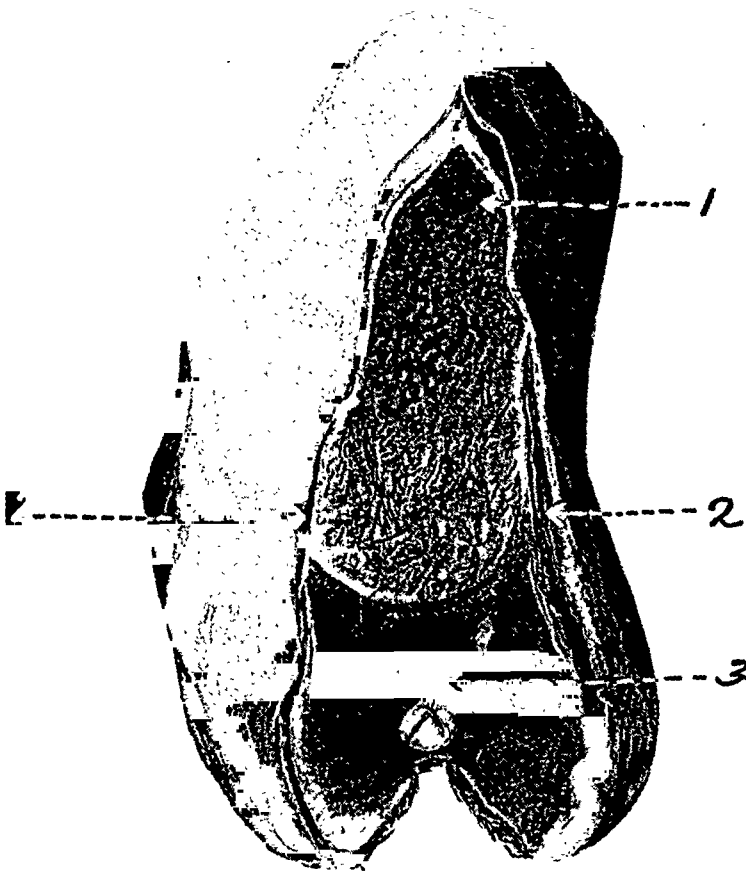


FIG. 1.—Intramural Calcification of the Gall-Bladder. 1—Calculus. 2—Intramural calcification. 3—Calcification evident in mucosa.

fibrosis, local aggregations of lymphocytes, depositions of calcium salts and of fascicular fatty crystals; the local areas of infection occurred in all three layers, the fibrosis with hyalinization, calcification and fatty degeneration were most marked in the zones of the muscularis and mucosa; there was a very constant relation between the fibrosis, hyalinization, infection, calcification and fatty degeneration.

(Osmic Acid Fat Stain.) Exhibited both localized areas of fat masses and also zones containing small globules of fat, and also some fat in distinct fascicular crystalline forms; in certain areas the tissue was in an early stage of degeneration and the particles of fat were very small and stained faintly.

Diagnosis.—(1) Intramural calcification of gall-bladder wall with associated cholesteatomatous degeneration and fibrosis, hyalinization and receding chronic cholecystitis. (2) Cholelithiasis (single cholesterol stone formation).

CASE II.—(By courtesy of Dr. A. L. Amolsch.) A white, obese, well-nourished, well-developed woman, aged forty-four years, mother of two children.

History.—The record showed no epigastric pain or gas but only habitual constipation. The terminal symptoms were acute epigastric and lower abdominal pain which subsided for a time, then recurred and localized in the lower abdomen and was accompanied with diarrhoea. The patient died with symptoms of intestinal obstruction and pelvic peritonitis. At autopsy the intestines were found angulated and adherent. In different areas abscesses were walled off and a general plastic exudative peritonitis prevailed. The origin of this was tubo-ovarian.

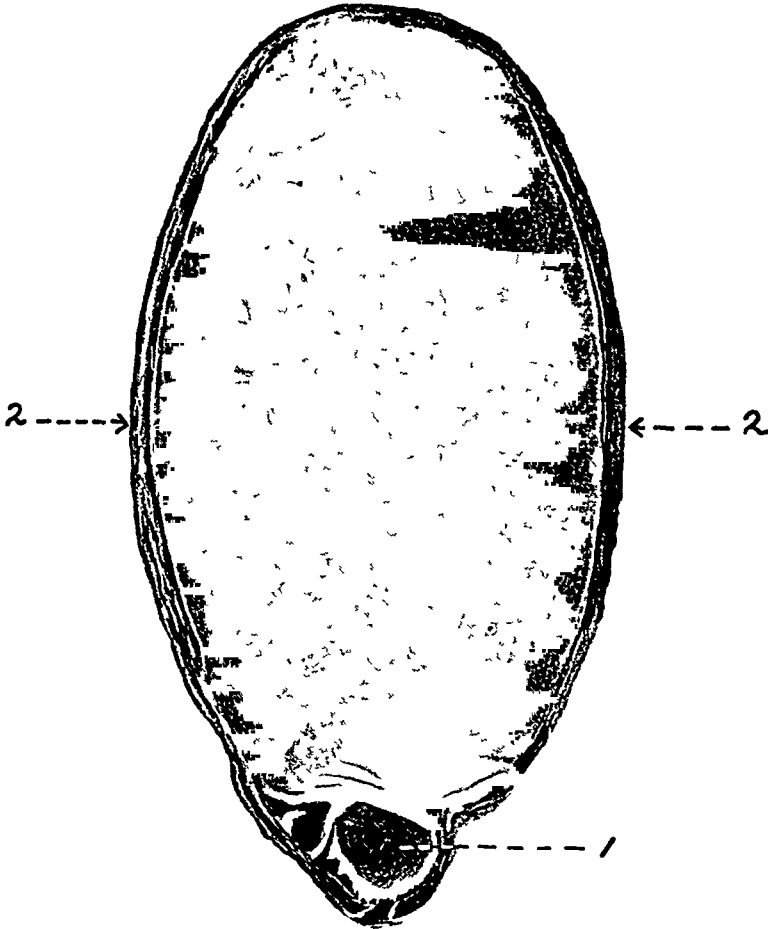


FIG 2—Intramural Calcification of Gall-Bladder. 1—Calculus. 2—Intramural calcification.

The gall-bladder (Fig. 2) was enlarged (7.5 by 4.5 centimetres by 2 millimetres in thickness) and of whitish color. Its wall was tense, fibrosed and calcified. The cystic duct was sharply angulated and it contained an impacted cholesterin stone which produced obstruction and inflammatory changes.

The mucosal surface was pale and the folds were obliterated. In the cut edge of the bladder wall laminations of inorganic depositions were plainly shown as eggshell-like formations. By translucent light and viewed from the mucosal surface mottled hard whitish areas were seen scattered throughout the entire wall. By palpation the wall imparted an eggshell and fibrous charactered impression.

Microscopically, the tissue had lost almost all of the mucosa and muscularis was pale, fibrosed and almost unrecognizable. The fibrous layer when stained, with osmic acid displayed globules of fat in place of the normal structure. The entire tissue was

extensively hyalinized and in numerous areas there were aggregations of infiltrated lymphocytes. Calcification was irregularly present in the middle and outer tissue zones.

Diagnosis.—(1) Chronic cholecystitis. (2) Cholangitis with stone formation in the cystic duct. (3) Intramural calcification and lipoidal degeneration of the gall-bladder wall.

Conclusions.—(1) The microscopical studies of two cases of intramural calcification of the gall-bladder showed positive evidence of long-standing cholecystitis and depositions of readily staining fat in considerable quantities. A very constant relation of fibrosis, hyalinization, infection, fatty degeneration and calcification obtained in each case.

(2) The physical character of each bladder wall when deeply palpated gave a broken eggshell sensation to the palpating fingers.

(3) Specifically diagnostic subjective clinical symptoms of intramural calcification are unknown. A small percentage of cases with cholecystitis of long duration and single stone formation may have calcification involving the bladder wall. X-ray delineation of a calcifying intramural process is the most satisfactory diagnostic means available.

(4) The gall-bladder wall may be easily broken by manipulation during its removal and a milky fluid contained in the bladder lumen freely spilled. This fluid is rich in fat and is usually sterile and causes no harm from leakage into the peritoneal cavity.

(5) In cases of long duration malignancy should be considered as a sequel to the irritation given by the degenerated tissues, particularly in the parts contiguous to the calcified masses.

BIBLIOGRAPHY

- ¹ Flörchen, H.: Quotes Aschoff and Kerr: *Deutsch. Zitschr. f. Chir.*, vols. ccxv, ccxvi, p. 264, 1929.
- ² Davis, J. E.: One of the authors of this paper.
- ³ Robson, A. W. Mayo: *Diseases of the Gall-Bladder and Bile Ducts*. Fig. 44, third edition, Wm. Wood and Co., New York, 1904.
- ⁴ Rolleston, H. D.: *Diseases of the Liver, Gall-Bladder and Bile Ducts*. W. B. Saunders Co., pp. 437, 613, Philadelphia, 1905.
- ⁵ Delafield, and Prudden: *Text-Book of Pathology*. Thirteenth edition, Wm. Wood and Co., pp. 62, 842, New York, 1925.
- ⁶ Adami, J. G.: *The Principles of Pathology*. Second edition, vol. 1., Lea and Febiger, pp. 926, 928, Philadelphia.
- ⁷ Stengel, and Fox: *A Text-Book of Pathology*. Seventh edition, W. B. Saunders Co., p. 101, Philadelphia, 1921.
- ⁸ MacCallum, W. G.: *A Text-Book of Pathology*. Second edition, W. B. Saunders Co., pp. 109-110, 408, Philadelphia, 1920.
- ⁹ Moynihan, B.: *British Med. Jour.*, vol. i, p. 1, January 7, 1928.
- ¹⁰ Bales, and Skinner: *International Jour. Med. and Surg.*, vol. xxxviii, p. 305, 1925.
- ¹¹ Holden: *Surgical Clinics of North America*, vol. xi, October, 1931.
- ¹² Moore, S.: *Diseases of the Gall-Bladder and Bile Ducts*, by Graham, Cole, Copher and Moore. Lea and Febiger, Philadelphia, 1928.
- ¹³ Kirklin, B. R.: Communication November 3, 1931, report of the past seven years' work at The Mayo Clinic, including 5,826 gall-bladder operations.
- ¹⁴ Standard Text-Books consulted: Boyd, Graham, Karsner, Kaufmann, Osler, Oxford Monograph vol. viii, Keen, Tice, Ashhurst, Graves, Rost, Rose and Carless, Thoma, Beattie, and Dickson, Babcock.

ACUTE PANCREATIC NECROSIS AND ITS SEQUELÆ

A CRITICAL STUDY OF THIRTY CASES

BY GEZA DE TAKATS, M.D., AND WALLACE D. MACKENZIE, M.B., CH.B.
OF CHICAGO, ILL.

FROM THE DEPARTMENT OF SURGERY OF NORTHWESTERN UNIVERSITY MEDICAL SCHOOL,
THE EVANSTON HOSPITAL AND WESLEY MEMORIAL HOSPITAL

THE development of pancreatic surgery since Körte's treatise,¹ in 1898, through the monographs of Heiberg,² in 1914, Gross and Guleke,³ in 1924, Schmieden and Sebening,⁴ in 1928, up to its present status, described in Wolfer's⁵ and Heller's⁶ reviews, contains all the clinical bibliography on the subject. In spite of the vast amount of experimental work and case reports the uncertainty of diagnosis and the high mortality have remained practically unchanged. Table I includes only three large statistics, and shows that, in comparison with other fields in surgery, very little progress has been made in reducing the mortality of acute necrosis of the pancreas.

TABLE I

Mortality of Acute Pancreatic Necrosis

Author	Year	Number of Cases	Mortality Per Cent.
Körte	1911	103	60
Guleke	1924	437	52.2
Schmieden and Sebening	1927	1278	51.2

In the present study, thirty cases of acute pancreatic necrosis or their sequelæ were analyzed, that entered the Evanston and Wesley Memorial Hospitals between 1920 and 1930. It represents the material of nine surgeons and is thus a fair average of what a patient may expect when struck with acute necrosis of the pancreas and taken to a large general hospital. Obviously the pre-operative management, the diagnosis, the operation and after treatment were not uniform in this series; however, while on a small material, this offered an excellent basis of comparing various methods of management. As a close correlation of physiological and pathological data with clinical observations is singularly lacking in most of the publications, we tried to point these out, with the hope that they may aid in lowering the mortality and untoward sequelæ of this disease.

Age and Sex of Patients.—(Table II.) Half of the patients (fifteen) were between the ages of forty and sixty. Schmieden and Sebening mention the case of a thirteen-year-old girl with a common-duct stone, who developed an acute necrosis. Cases are on record at the ages of two and one-half, three, four and seven years.⁷ However, the occurrence of the disease below twenty years must be very rare and was not observed in our series.

ACUTE PANCREATIC NECROSIS

TABLE II

Age and Sex of Patients

Decades	Number of Cases
20-30	6
30-40	5
40-50	7
50-60	8
60-70	3
80-90	1
	—
	30

Half of the patients were between the ages of 40-60.

Number of men 12

Number of women 18

The incidence of sex was twelve male to eighteen female patients. The slight preponderance of the female sex is present in all of the large statistics and is undoubtedly due to the important rôle of gall-bladder disease in the etiology.

The Clinical Picture.—Recurrent attacks of upper abdominal or right hypochondriac pains were elicited in nineteen patients, whereas eleven denied having any previous attacks. The clinical symptoms of the last attack for which the patient came to the hospital were as follows. (Table III.)

TABLE III

Clinical Signs and Symptoms of Acute Pancreatic Necrosis

Symptoms and Signs	Number of Cases
Pain in epigastrium with general irradiation.....	30
Reverse peristalsis (nausea, vomiting, acute gastric dilatation)....	23
Jaundice or clay-colored stools.....	12
Pain in right upper quadrant and right shoulder.....	10
Pain in epigastrium, irradiating to the left.....	7
Muscle rigidity	3
Palpable mass	1

The pain of acute pancreas necrosis is excruciating. One of our own patients, who had just gone through childbirth, stated that this annihilating pain was far worse than anything she had ever experienced. While the radiation to the right upper quadrant and shoulder seem natural in view of the frequent association with gall-stones and common-duct stones, the irradiation to the left, mentioned in seven instances, requires some discussion. Katsch⁸ emphasized that irradiation to the left in a gall-bladder colic is suggestive of pancreatic involvement. When one realizes that most of the gland lies to the left of the mid-line, an involvement of the body or tail of the pancreas may easily give such irradiation. It is probable that on careful questioning such a symptom and the occurrence of Head-zones on left-sided segments could be more often elicited.

Jaundice in twelve cases shows that obstruction of bile flow may frequently complicate the picture. Common-duct stone, cholangitis or a swelling of the head of the pancreas are the most commonly quoted causes. However, one must consider the possibility of a toxic hepatitis, a fatty degeneration of the liver or even an acute liver atrophy, as observed in one case of the present series. The serious general intoxication that follows autolysis of the pancreas may be responsible for the hepatic damage. Wolfer⁹ has recently summarized and advanced new evidence of a possibility of pancreatic digestion of the biliary tract and liver substance through a backflow of pancreatic enzymes into the common duct in the etiology of certain types of cholecystitis. Whether such a mechanism could also operate during an attack of acute necrosis of the pancreas has not yet been investigated.¹⁰ At present, the hepatic injury can be best explained by the severe intoxication with protein-split products or an ascending pylephlebitis. Uræmia in connection with hepatic damage has been reported,^{11,12} and is part of the general intoxication in severe jaundice.

Muscle rigidity does not belong to the typical picture of acute necrosis of the pancreas. In all three cases of our series a diffuse, purulent peritonitis was present. Thus it must be considered as a late sign of serious prognostic value.

A palpable mass in the epigastrium was noted in one case. In thin individuals, with a gastropnoia, the normal pancreas can be palpated at times; swelling, or induration in such a patient, can be palpated a few hours after the onset. Usually, however, the gastric and colonic distention, which is an almost constant symptom of retroperitoneal exudates or hæmorrhages, prevents the palpation of any mass.

Laboratory Examinations.—*Blood counts.*—(Table IV.) Red blood counts above 5,000,000 were obtained in nine cases. The hemoglobin was correspondingly high. The counts were all taken on entrance to the hospital. The first seven cases were obviously dehydrated, had not taken enough fluids while being sick at home. These high counts would indicate the necessity of parenteral administration of fluids on entrance to the hospital. The last two cases with unusually high red counts must have been both in shock. Case XXIV entered the hospital in the middle of the night with a red count of 7,000,000. Next morning the count was 5,900,000. She was operated on the third day of her entrance and recovered. Case XXX entered the hospital with a count of 8,300,000 and a hemoglobin of 140 per cent., in "agony." The patient was operated on twelve hours after the onset of the attack and died forty-eight hours later. Twenty-four hours after the operation the red count was 5,650,000, with 94 per cent. hemoglobin. The value of interpreting these high red counts as an index of shock has not been utilized in pancreatic surgery. The difference between capillary and venous red cell counts should be a good estimate of the amount of shock,¹³ and should certainly warn against immediate operation.

ACUTE PANCREATIC NECROSIS

TABLE IV

Red Cell Counts Over 5,000,000 in Acute Pancreatic Necrosis

Case No.	Red cell count	Hemoglobin	Remarks
1	5,500,000	80	Vomited for three days
3	5,700,000	100	Nauseated—nothing by mouth for three days
4	5,208,000	100	No food or liquids for five days
14	5,400,000	70	Sick at home for nineteen days
16	5,650,000	98	Vomited for four days
20	5,440,000	95	Pyloric stenosis
21	5,400,000	90	Vomiting three days
24	7,000,000	?	Five hours after onset
30	8,300,000	140	In shock, ten hours after onset

An unusually low red count (2,230,000, with 55 per cent. hemoglobin) was obtained in Case VII, a deeply jaundiced patient, who died forty hours after the operation. Post-mortem revealed an acute yellow atrophy of the liver.

The other patients showed a moderate secondary anæmia, which is well explained by an elevated temperature, the chronic toxæmia and the fact that they had overcome the initial dehydration.

White Counts.—(Table V.) Leucocyte counts are available in every case and show a great deal of variation. The value of white counts in acute abdominal conditions is probably over-emphasized. So many factors, such as infection, hæmorrhage, shock, dehydration, influence it, so that it can be used only as supportive or additional evidence in diagnosis. Even acute pain produces a leucocytosis.¹⁴ Nevertheless, in this small series it is obvious that white counts below 15,000 were observed either in patients with diffuse peritonitis, whose counts were 3,800 and 4,700 respectively, or in patients with late sequelæ of acute necrosis, such as cysts or chronic pancreatitis. It seems that all cases in the acute stage had a white count above 15,000 and that there were four cases with a count of over 30,000. Two of these patients had a fulminating gangrene and died, while two had late pancreatic abscesses and recovered.

TABLE V

Leucocyte Counts in Acute Pancreatic Necrosis and Its Sequelæ

White Count	Number of Cases	Remarks
Below 5,000	4	Diffuse peritonitis 2 Chronic pancreatitis 2
5,000–10,000	5	Chronic pancreatitis 3 Pancreatic cyst 2
10,000–15,000	2	Chronic pancreatitis 2
15,000–20,000	8	Subacute cases 6 Terminal in shock 2
20,000–30,000	4	Acute biliary infection 2 Acute pancreatic necrosis .. 2
Above 30,000	4	Hyperacute necrosis..... 2 (both died) Abscess of the pancreas 2

Differential white counts were made in eight patients, three of which showed a neutrophil polymorphonuclear count of over 85 per cent. The differential white count, including the Schilling-Arneth count, has been studied by some authors.^{15, 16} The shifting of the leucocytes to the immature forms seems a constant finding but is not specific and is found in any acute destructive process. Its prognostic value has been repeatedly emphasized by Schilling¹⁷; but only a few of our clinical technicians are trained to use it and its use has not become general.

Examination of the Urine.—Abnormal findings are listed in Table VI. The severe intoxication is again manifested by the frequent appearance of albumen and casts. The occurrence of glycosuria in four cases indicated a disturbance of the internal pancreatic secretion, although it is known that diffuse peritonitis may also produce it. Aceton and diacetic acid were found twice but probably were not determined in every case.

TABLE VI

Urinary Findings in Acute Pancreatic Necrosis

Missing reports	4
Negative	2
Albumen	11
Granular and hyalin casts	9
Sugar	4
Aceton plus diacetic acid	2
Red cells	2

Blood Sugar.—Such determinations are available in six cases, and gave the following readings (Table VII): Of the six cases, three were not acute; the other three were taken shortly after the operation and showed an elevation of blood sugar. In not one case was a pre-operative determination made.

TABLE VII

Blood-sugar Determinations in Acute Pancreatic Necrosis and Its Sequelæ

Case No.	Blood Sugar in mgs. per 100cc.	Remarks
2	75	On sixth post-operative day, two days before death
17	95	Chronic pancreatitis; two years after cholecystectomy
20	92.7	Sclerosis of the head of pancreas
23	142	Third post-operative day
26	131.5	Sixth post-operative day
27	220	Two years after acute necrosis Post-hæmorrhagic cyst

Sugar Tolerance.—Only once was this test performed, in Case XXVI. The values were 122, 227, 272 and 219 milligrams per 100 cubic centimetres of blood taken at 0, $\frac{1}{2}$, 1 and 2 hours after the ingestion of 1.75 grams of dextrose per kilogram body weight. The tolerance was determined one week after the operation for an acute necrosis of the pancreas and shows a definitely diabetic curve. A total of 4.93 grams of sugar were excreted in the urine. Later determinations are unfortunately not available.

Examination of Peritoneal Exudate or Content of Cysts.—In Case X, which seemed to be a case of chronic fat necrosis with a large and quickly refilling peritoneal exudate and no history of acute attack in the chart, the fluid contained bile, 10 per cent. albumin (due to blood) and cultures were negative. In Case XXII, fluid aspirated from an oedematous pancreas revealed pseudo-diphtheroid bacilli, probably a contamination. Except in those two cases, there is no report of chemical or bacteriological study of the exudate except at autopsy.

In two patients the content of cysts was examined for bacteria and was found sterile in two and four days respectively. No anaërobic cultures were made.

Blood Chemistry.—Aside from the blood-sugar determinations, one re-



FIG. 1.

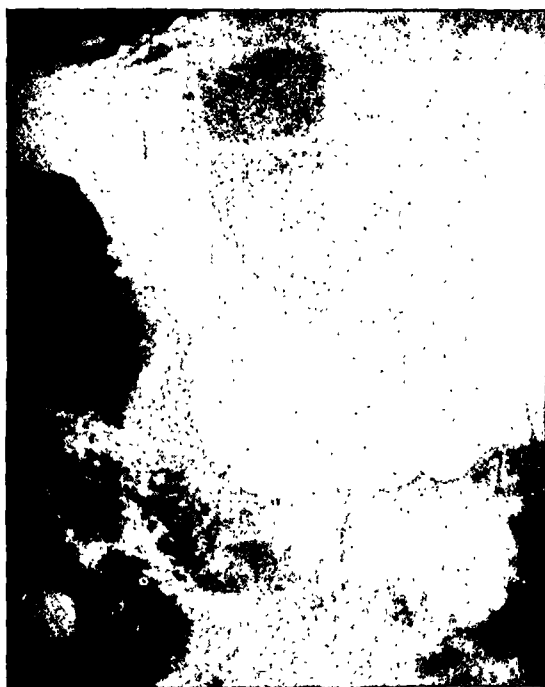


FIG. 2.

FIG. 1.—Case of G. de Takats. Mrs. E. S., aged forty-five. Recurrent attacks of gall-bladder colic with jaundice. Last attack two weeks ago with marked irradiation to the left. Note the irregularity on the greater curvature, which is permanent, and large duodenal curve. At operation a marked enlargement of the head of the pancreas and perigastric adhesions explained the röntgenological findings.

FIG. 2.—Case of G. de Takats. Th. M., aged thirteen. Abscess of the tail of the pancreas, making an impression high up on the greater curvature. The rigid, mottled appearance of the greater curvature simulates malignancy. The abscess was drained toward the flank.

port is available in Case XX of a non-protein nitrogen of 48.4 (normal 35) and a urea nitrogen of 23.3 (normal 15) milligrams per 100 cubic centimetres of blood. This patient had had an operation for pancreatic cyst thirteen years before and returned because of intermittent duodenal obstruction, which was undoubtedly responsible for the high split products. No such determinations are available in acute necrosis of the pancreas, although they would be undoubtedly high.

X-ray examinations are available in five cases. None of these was taken during an acute attack. In acute attacks, the absence of subdiaphragmatic air may exclude gastroduodenal perforation and reveal intestinal obstruction by the aspect of fluid levels. A flat plate on a portable apparatus should

have a definite value in excluding the most frequent conditions that obscure the diagnosis of pancreatic necrosis. Such a diagnosis by exclusion would be very important in determining the optional time of operation, as will be discussed later.

In the absence of acute abdominal symptoms, when a barium meal can be given, the value of X-ray examinations has been emphasized by Case¹⁸ and others. The irregularity on the greater curvature, a pyloric stenosis, a displacement of the transverse colon downwards and stomach upwards, the exaggeration of the duodenal curve are the most frequently observed signs. A few films of our own series serve to illustrate these. (Figs. 1, 2 and 3.)

Time of Operation.—Most statistics bring convincing proof to the effect that in case of acute pancreatic necrosis immediate operation is necessary and that delay raises mortality. Only quite recently have Nordmann, Walzel and Polya expressed their belief that the operation is not capable of arresting the autolytic process and the absorption of protein-split products. They advise against immediate operation and feel that after sequestration or abscess formation, the patient is in far better condition to stand surgical interference. That light cases may be treated conservatively seems uniformly accepted; the discussion centers around the patients, who show from the beginning a severe intoxication and a beginning peritonitis. Previous to their objections, Archibald¹⁹ advocated deferring operation in hyperacute cases with collapse because such patients would not stand the operative interference.

Our cases, although far too limited in number to allow definite conclusions, throw an interesting light on the subject. Table VIII shows the time of operation related to the onset of acute symptoms. It is realized that statistics of this kind are open to criticism; so much depends on other factors, such as the skill of the operator, the severity of the attack, the type of operation, that the time factor alone may not be decisive. However, the immediate operation (less than twenty-four hours) and the late operation (after three weeks) show the lowest mortality. Operations performed in the interval have a mortality of 50 per cent., which is the usually quoted figure in recent mortality statistics (Table I).

TABLE VIII

Time of Operation Related to Onset of Acute Symptoms

Time	Number of Cases	Number of Deaths
Less than twenty-four hours.....	4	1-25%
Twenty-four to seventy-two hours.....	2	1-50%
Three days to a week.....	3	1-33%
One to two weeks	4	2-50%
Two to three weeks	3	2-66%
More than three weeks	5	1-20%

Patients operated on within the first twenty-four hours or after three weeks (nine cases) have an average mortality of 22 per cent.; patients operated on after twenty-four hours but earlier than three weeks (twelve cases) have a mortality of 50 per cent.

That the hyperacute cases may be in shock and have a high red cell count was shown in Table IV. Operation should certainly be deferred in

such patients. In cases that already show evidence of diffuse peritonitis, waiting for localized abscesses would correspond to Ochsner's principles. There is no evidence on hand to show that drainage of the omental bursa, of the biliary tract or of the peritoneal exudate would in any way influence the spreading of necrosis or the virulence of peritonitis. The fulminating cases seem to die, no matter what treatment is instituted; but Nordmann's two cases²⁰ would indicate that even seemingly moribund patients may be successfully operated on at a later time.

Operation is then most favorable in the early cases that have an œdema of the pancreas without any other involvement; many of these cases subside on conservative treatment and just which would go on to a progressive destruction is impossible to tell. The crux of the situation, however, is this: Can we, with our present diagnostic ability, be sure that we are really dealing with an acute pancreatic necrosis, and not overlooking another type of acute abdominal emergency where delay is fatal? We feel that with a flat X-ray plate gastroduodenal perforation and intestinal obstruction can be excluded; that high blood sugar and high blood diastase content, in the absence of diffuse peritonitis, points to pancreatic involvement with great emphasis. In such patients delay is permissible and may be life-saving; but if in doubt, a rapid exploration is seriously to be considered, if the patient can be brought out of the initial shock.

It is unwise to attempt to lay down hard-and-fast rules for the time of operation, as every case presents a different problem. However, the following principles seem logical to follow.

- (1) Never operate on a patient in the initial shock.
- (2) If all diagnostic measures point to pancreatic necrosis, delay is permissible, until abscesses localize, cysts or gangrenous parts need removal.
- (3) If the diagnosis is uncertain, early operation must be done for fear of overlooking intestinal (appendix) perforation.
- (4) If the attack is mild, wait for recovery and then diagnose and operate for biliary-tract infection.

Pre-operative Diagnosis.—Table IX shows the pre-operative diagnosis, as listed on the charts. From this table it is apparent that a diagnosis of acute pancreatic necrosis was not made in one single instance. It is naturally possible that the attending men might have considered such a possibility, but as most hospitals do not require a pre-operative diagnosis from the surgeon before he operates, the interne's diagnosis may be the only one on the chart. Nevertheless, it illustrates the difficulty of diagnosis unless certain laboratory methods will be used. The diagnosis of acute cholecystitis and of common-duct stone has been made in fifteen out of the twenty-two cases, which is essentially correct, being the etiological factor. The involvement of the biliary tract has been found in eighteen out of the twenty-two cases, which gives an 81.2 per cent. incidence of biliary infection as the primary cause. This corresponds to figures given in larger statistics. The diagnosis of intestinal obstruction has been made twice; vomiting and marked colonic distention

are usually present, the transverse mesocolon is œdematous and a paralytic ileus is always present in such sudden retroperitoneal accumulations of fluid. Whether it is ever possible to differentiate this from a mechanic obstruction in the left half of the colon cannot be stated. In such patients, with shock and a low blood-pressure, the use of spinal or splanchnic anæsthesia for diagnostic purposes would not be advisable. Hypertonic sodium chloride solutions overcome paralytic ileus astonishingly well²¹ and could be tried. The most important point, however, in ruling out the erroneous diagnoses is the attempt to make a positive diagnosis of acute necrosis of the pancreas by the high fasting blood sugar and high diastase content of the blood. There is only one condition which clinically simulates acute pancreatic necrosis and produces the same laboratory data, and that is a diffuse purulent peritonitis. Unless an appendix-peritonitis or a ruptured ectopic pregnancy can be definitely ruled out, such a possibility must always be kept in mind. The flat X-ray plate will help to diagnose a ruptured viscus by the accumulation of air and the disappearance of liver dullness.

TABLE IX

Pre-operative Diagnosis

<i>In Case of Acute Necrosis</i>	<i>In Case of Late Sequelæ</i>	
Acute cholecystitis 12	Pancreatic cyst 2	} Correct
Common-duct stone 3	Pyloric obstruction due to pre- viously drained cyst 1	
Intestinal obstruction 2	Carcinoma of pancreas 1	
Post-operative ileus 1	Intestinal obstruction 2	} Erroneous
Perforated gastric ulcer 1	Tuberculous peritonitis 1	
Ruptured appendix 1	Hepatic cirrhosis with ascites.. 1	
Ruptured ectopic pregnancy .. 1		
Acute cardiac decompensation.... 1		
—	—	8
22		

In the late cases, a correct diagnosis has been made in three out of eight instances. These diagnoses were made chiefly possible by the use of a barium meal. In the other cases, the hard nodular pancreatitis, that may follow acute necrosis, gave rise to the diagnosis of carcinoma of the head of the pancreas in one instance. A differentiation of these two conditions may not be possible even on exploration. A biopsy of the inflamed pancreatic tissue is listed as one of the possible causes of acute pancreatic necrosis by Schmieden and Sebening.⁴ Peripancreatic adhesions and infiltrated omental tags may produce intestinal obstruction. One of us has seen an abscess in the tail of the pancreas, which produced an obstruction at the splenic flexure. Thus the diagnosis of intestinal obstruction as one of the late sequelæ of acute pancreatic necrosis must be considered and cannot be listed as a diagnostic error. The diagnosis of tuberculous peritonitis and of hepatic cirrhosis with ascites has been made. This is due to the appearance of a large peritoneal exudate in some of the late cases of pancreatic necrosis, where large areas of fat necrosis, thickening of the omentum and infiltration of the mesocolon testify to the origin of this disease. The palpable masses

ACUTE PANCREATIC NECROSIS

in the omentum may very easily suggest tuberculous peritonitis, whereas the rapid refilling of peritoneal exudate and perhaps a palpable small liver may suggest portal cirrhosis. That the liver is frequently damaged in acute pancreatic necrosis has already been mentioned and will be discussed later.

Findings at Operation.—Table X indicates the findings at operation, related to mortality. When we compare this table with Table VIII, which deals with the time-factor as related to mortality, we find that early operation (less than twenty-four hours) and early anatomical findings (œdema or hæmorrhagic exudate without necrosis) will give the lowest mortality. Provided the patient is not in shock or can be brought out of it in a few hours, this seems the most logical procedure, although some of these patients would probably recover without an operation. On the other hand, patients with certain pathological findings such as acute liver insufficiency and diffuse peritonitis cannot be benefited by an immediate operation, but probably harmed. Abscess or gangrene, when the patient has overcome the spread of infectious or destructive process, do better when opened late. Post-operative pancreatic necrosis, which occurred after operations on the gastroduodenum or biliary tract, proved fatal in all cases. Here the complication was not recognized, the patient was already weakened by the previous operation and the digestion of ligatures and sutures by pancreatic enzymes played a decisive rôle in the fatal outcome.

TABLE X

Main Pathological Findings at Operations for Acute Pancreatic Necrosis

Findings	Number of Cases	Mortality
œdema without necrosis
œdema with fat necrosis	1	..
Sclerosis with fat necrosis	2	..
Cyst with fat necrosis	2	..
Hæmorrhagic exudate	7	1
	—	—
	12	1 8.3%
Abscess or gangrene	5	2
Acute hepatic injury	1	1
Diffuse peritonitis	1	1
Post-operative pancreatic necrosis	3	3
	—	—
	10	7 70%
	—	—
Total cases	22	8 36.3%

This table, although the number of cases is small, would again urge operation early, when shock is absent. If, however, the patient is seen at a later stage, expectant waiting is advisable. It is true that some patients will die in this interval, but the number of surgical deaths will be higher. An adequate control-series has not been forthcoming and is very difficult to obtain in clinical cases.

The absence of early œdema without fat necrosis in the operative findings would indicate that the diagnosis has not been made so early or that indica-

tion for surgery was not deemed to be present in this series. In several statistics, 4, 7, 22 patients have been operated on with acute œdema of the pancreas and no other findings with a low mortality. Whether they would have recovered without an operation or gone on to progressive destruction, no one can tell at the onset. Hence again, a very early operation should be postulated.

Surgical Procedures in the Treatment of Pancreatic Necrosis and Its Sequelæ.—The grouping of operations as shown in Table XI may seem arbitrary and the mortality figures not conclusive, as so much depends on the pathological findings. However, the first group with minimal interference shows a comparatively low mortality in spite of the fact that some of the most advanced cases are included in it; whereas the second group, with attempts at drainage of the general peritoneal cavity or extensive surgery on the biliary tract, shows a high mortality. Finally, the third group includes operations for late sequelæ, with no mortality in the three cases.

TABLE XI

Surgical Procedures in the Treatment of Acute Pancreatic Necrosis and Its Sequelæ

Type of Operation	Number of Cases	Mortality
Exploratory laparotomy, no drainage.....	2	..
Cholecystotomy	1	..
Cholecystectomy	2	..
Drainage of lesser sack	3	1
<i>Cholecystotomy plus drainage of lesser sack.....</i>	<i>3</i>	<i>1 18%</i>
Cholecystotomy plus drainage of peritoneum	7	5
Cholecystectomy plus drainage of lesser sack.....	1	1
<i>Cholecystectomy plus drainage of common duct.....</i>	<i>1</i>	<i>1 77.7%</i>
Gastroenterostomy for pyloric obstruction	1	..
Drainage of pancreatic cyst.....	1	..
Drainage of abscess	1	.. 0%

The object of any surgical interference in acute pancreatic necrosis is first of all to drain the infected biliary tract, if that is the primary cause of the disease. Such was the case in over 80 per cent. of this series and is probably even higher if special attention is focused on this source. The drainage of the gall-bladder is the simplest and most rapid form of drainage. While cholecystectomy and common-duct drainage would be the ideal procedure and could be done in patients at an early stage of the disease by skilled surgeons, most patients may not stand so much at the time of acute pancreatic necrosis and should have just as little done as possible. The drainage of the omental bursa and the capsule of the pancreas if it is filled with exudate can do no harm and decompresses the gland. The drainage of the peritoneal cavity is useless and impossible. While arguments are still unsettled as to whether the peritoneal fluid is toxic or protective, it seems to be sterile in the early cases. Later, when permeability changes occur, a diffuse purulent peritonitis is present, containing the flora of the intestinal canal. In either case, drainage is of no avail.

ACUTE PANCREATIC NECROSIS

Incision of the capsule or even liberation of the gangrenous portion by the gloved finger has been practiced by many Continental surgeons. Walzel²³ has reported a rupture of the splenic vein following such a procedure, which led to a fatal hæmorrhage and warns of any incisions into the parenchyma itself.

It is interesting to note that a simple exploration, during which the condition was not recognized but where tissue taken for biopsy revealed fat-necrosis, has led to recovery in two instances. This confirms our opinion of spontaneous recovery even in the presence of a large peritoneal exudate.

On the basis of these figures and convincing reports of Nordmann, Heller and others, we would emphasize *biliary drainage* before anything else is done, if infection or stones are recognizable. In case of a large retroperitoneal œdema, this could be drained toward the flank. There is no way of preventing progressive necrosis and intraglandular manipulations may do more harm than good. As secondary operations, removal of the gall-bladder, opening of pancreatic abscesses, removal of sequestered glands, overcoming pyloric or intestinal obstructions may be done with comparative safety.

Complicating Factors and Their Influence on Mortality.—Table XII lists the complications encountered and diagnosed. Pancreatic asthenia is not listed.²⁴ The association of parotitis and pancreatitis has been the subject of a great many discussions. We refer to the article of Schmieden and Voss.²⁵ As following other laparotomies, its appearance is an ominous prognostic sign. The thrombosis of the portal vein or its tributary, the splenic vein, has occurred twice, a portal hypertension with ascites twice. This is not surprising, when one realizes the fulminating destruction of tissue that occurs in the area these veins supply. Surgery is helpless in such a complication. An acute swelling of the liver was seen once during operation. This subject has been thoroughly discussed recently by Henschen,²⁶ although not in connection with pancreatic disease. It calls for biliary drainage perhaps even through hepatic parenchyma. Our one case recovered.

TABLE XII

Complicating Factors and Their Influence on Mortality of Acute Pancreatic Necrosis

Complications	Number of Cases	Deaths
Bilateral parotitis	1	1
Thrombosis of splenic vein	1	1
Portal thrombosis with infarct	1	1
Portal cirrhosis with ascites	2	2
Toxic hepatosis	1	1
Pleural empyæma	1	..
Subphrenic abscess	1	..
Nephrosis with anuria	1	1
	—	—
Total complications	9	7 77.7%

Pleural empyæma and subphrenic abscess are not infrequently seen as a late complication. Their adequate drainage resulted in cure. One patient died of an acute kidney-insufficiency with complete anuria. We have referred

to this complication as a sequel to hepatic injury. It is probably part of the general toxæmia.

The Total Mortality Rate.—Of the thirty patients, eleven died, thus giving a mortality of 36.6 per cent. Eight patients were operated on for late sequelæ, which leaves twenty-two cases of acute pancreatic necrosis with eight deaths, a mortality of 36.6 per cent. This is surprisingly less than the statistics shown in the first table, which vary around 50 per cent. It is pos-



FIG. 3.—Case of G. de Takats. Mrs. E. C. The stomach is large, deformed and empties slowly. The pyloric half of the stomach, on the greater curvature, is displaced upward and toward the left. The duodenal curve is spread out over a larger area than usual. The stomach empties in eight hours. (Report of Dr. J. T. Case.) This was a case of a huge pancreatic cyst, involving the head and body of the pancreas with marked perigastric adhesions. The suture of the cyst wall to the abdominal wall produced a partial pyloric obstruction.

sible that the delay in operating on these non-diagnosed cases unintentionally improved the surgical risk. Also, the frequent use of biliary drainage without any operations on the pancreas, whose involvement has not been suspected at the time of operation, may have improved the statistics. Thus of the twenty-two cases only four came to operation within the first twenty-four hours; whereas in Jung's statistics (*cit. Guleke*³) nine out of nineteen, in

ACUTE PANCREATIC NECROSIS

Stephan's material four out of eleven and in Zoepffel's cases four out of fourteen came to operation within the first twenty-four hours. Curiously enough, these statistics were compiled to prove that early operation improves the mortality. A glance at Zoepffel's table indicates exactly the same findings that we have arrived at, but interpreted differently: namely, that if the patient is not seen and operated on within the first twenty-four hours, the operation should be deferred to a later period of localizing symptoms. The fact that so many patients die if operated on after twenty-four hours was interpreted as a proof for earlier operation. We are thoroughly in agreement with those who postulate early operation, in the stage of œdema. If, however, necrosis is present, if the patient is first seen three or four days after the acute onset, then conservative treatment, at least for the time being, appeals more to us.

Late Sequelæ of Acute Pancreatic Necrosis.—The patient, who has once gone through an attack of acute pancreatic necrosis, is not safe from late complications. Table XIII lists only one case of recurrent attack, which would be about 4 per cent. of all acute attacks. In reëxamining a number of patients, we frequently hear of recurring epigastric pain, indigestion, nausea and distention. If the biliary-tract infection had been the primary cause, and only an emergency cholecystotomy was done, these recurrent mild attacks indicate a cholecystectomy, and, if necessary, a common-duct drainage. Another cause for recurrent symptoms which requires operation is late sequestration of gangrenous pancreatic tissue, which may have to be removed years after the first operation. The appearance of a persistent pancreatic fistula, with its digestive action on the skin, also needs surgical interference, if it does not close spontaneously in about six months. It may be due to small gangrenous patches of glandular tissue or to a secreting true cyst, whose endothelial lining has not been destroyed. Hohlbaum²⁷ implanted the secreting pancreatic stump or the wall of the cyst into an upper jejunal loop in three patients. This method deserves serious consideration in suitable cases.

TABLE XIII
Late Sequelæ of Acute Pancreatic Necrosis

	Number of Cases
Recurrent mild attacks	1
Recurrent acute necrosis	1
Persistent fistula	1
Sclerosis of the pancreas	1
Pancreatic cyst	2
Pyloric stenosis following drainage of cyst.....	2
Diabetes	2
Incisional hernia (6 cases examined)	5

A sclerosis of the pancreas is listed in one case, which had been explored two years after the original attack. There are usually marked digestive disturbances present and a prolonged common-duct drainage or a splitting of the pancreatic capsule, as advocated by Payr and Martina,²⁸ seem indicated.

No such operations were performed in this series. The operation is not entirely without danger, as acute necrosis and pancreatic fistula may develop after splitting of the adherent capsule.

A pyloric stenosis developed in two cases following suture of the cyst wall to the peritoneum. One patient had a gastroenterostomy, while the other had only a slight intermittent attack of obstruction, although there was a large eight-hour residue of barium. (Fig. 3.) This observation would warn us not to resect too much of the cyst wall in future, as too much tension of the cyst when sutured to the abdominal wall may obstruct the pylorus or cause a marked distortion of the stomach. Two pancreatic cysts have been operated on; both were peripancreatic pseudo-cysts, the results of a previous hæmorrhagic exudate in the omental bursa. A case observed by one of us (de T.) had an acute pancreatic necrosis right after childbirth. The gall-bladder was drained by the obstetrician with the diagnosis of an acute cholecystitis and the pancreas not explored. She was first seen and operated on by us two years later for a large peripancreatic cyst.

Diabetes developed in two cases that have been known to be sugar-free before the acute necrosis set in. This would correspond to almost 10 per cent. of all cases. That latent disturbances of carbohydrate metabolism exist in a larger percentage of cases has recently been frequently discussed.²⁹

We were able to obtain post-operative sugar tolerance curves on four other patients, two of which showed abnormally high curves (Chart I). Naturally, the time elapsed since the operation is an important factor, since the great regenerative power of the pancreas, particularly in younger individuals, may overcome even quite serious loss of pancreatic tissue.³⁰ In older individuals, or in patients who develop a chronic pancreatic sclerosis following acute necrosis with fatty diarrhœa, a decrease in sugar tolerance should be looked for.

One patient had attacks of fatty diarrhœa which could promptly be controlled with tablets of pancreatic extract.

Five out of six patients had an incisional hernia at the site of drainage.

Autopsy Records.—Death occurred in eleven out of thirty cases, a mortality of 36.6 per cent. Of the eleven deaths, seven came to autopsy. The main findings are listed in Table XIV. Pancreatic necrosis was naturally present in all cases as evidenced by gangrenous masses in the gland and fat necrosis spreading through the mesocolon, omentum and not infrequently in perirenal tissue. Its chief spread is through the lymphatics. The peculiar blotchy, lattice-like cyanosis, that is not infrequently present during life, is an important diagnostic sign, according to Walzel,³¹ and does not disappear after death. One of us (de T.) has repeatedly seen it on the autopsy table. Its mechanism has never been explained although a stasis of the superficial abdominal veins, accentuated by a sudden increase of pressure in the vena cava, is a possible explanation. There is no fat necrosis in the abdominal wall, but the subcutaneous fat is frequently pale and œdematous.

ACUTE PANCREATIC NECROSIS

TABLE XIV

Autopsy Records

Main Pathological Findings in Seven Cases

Findings	Number of Cases	Findings	Number of Cases
Pancreatic necrosis	7	Sero-fibrinous peritonitis	2
Cholelithiasis	4	Purulent peritonitis	2
Common-duct stone	2	Thrombosis of splenic vein	1
Acute cholangitis	1	Portal thrombosis	1
Focal liver necrosis	2	Pleural empyæma	1
Fatty degeneration of the liver	1	General septicæmia	1
Acute yellow atrophy	1	Hæmorrhage into adrenal gland.....	1

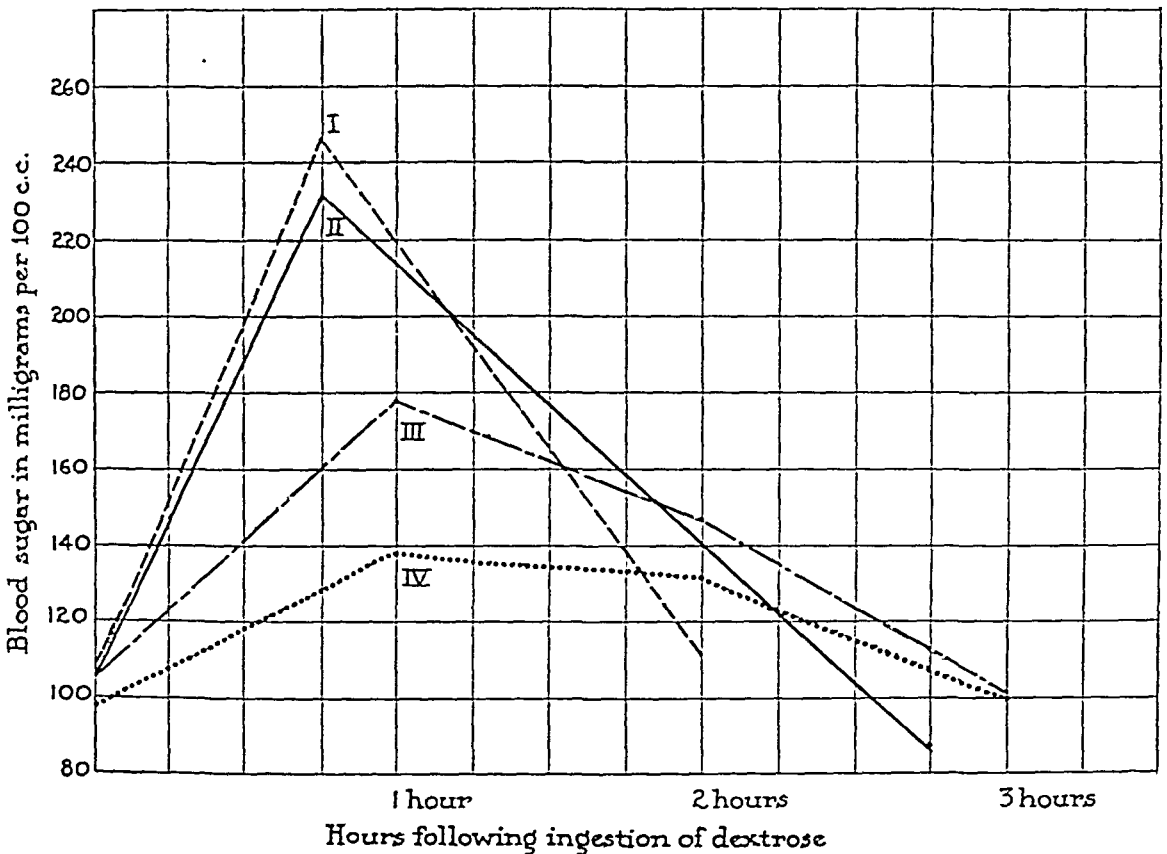


CHART I.—Sugar-tolerance curves in four patients several years after acute pancreatic necrosis. Cases I and II had fifty grams of dextrose in 25 per cent. solution, and samples of finger-blood were taken at forty-five minutes and two hours. Cases III and IV received 100 grams of dextrose and samples were taken at one, two and three hours. The four curves, then, are not entirely comparable. Nevertheless, it is obvious that the first two patients, in spite of the smaller amount of dextrose, showed a very sharp rise of blood sugar, whereas the latter two show normal peaks. None of these curves can be called diabetic, but the sharp initial rise is suggestive of poor glycogen fixation in the liver and has been seen in mild diabetic cases. (Noorden and Isaac: *Die Zuckerkrankheit und ihre Behandlung*. Eighth Edition, p. 157, Julius Springer, Berlin, 1927.) The slow fall in Cases III and IV may be due to their age. Case I.—Mrs. J. M., aged forty-eight, six years after operation. Case II.—Mrs. E. G., aged forty-four, seven years after operation. Case III.—Mrs. M. W., aged seventy, seven years after operation. Case IV.—Miss J. J., aged fifty-two, two years after operation.

The high incidence of gall-stones, common-duct stones and biliary-tract infections corresponds to the findings on the operating table. Attention should be drawn to the occurrence of liver damage, which may be the immediate cause of death by hepatic insufficiency.

Peritonitis has been noted in four cases. The exudate is first sterile and later becomes infected by the intestinal flora. The two sero-fibrinous exu-

dates have not been cultured, one of the purulent exudates yielded *B. coli* and anaërobic Gram-positive cocci and bacilli and Gram-negative bacilli. In Brütt's series,³² the peritoneal exudate was sterile in twelve out of seventeen cases, two showed *B. coli* and three staphylococci. Liver and pancreas were sterile in 64 and 50 per cent. respectively, the rest showed aërobic and anaërobic bacteria. This is of great interest because of Dragsted's³³ work on the importance of anaërobic bacteria in the toxicity of autolytic products. That a sudden gangrene of the pancreas would serve as an excellent medium for previously dormant bacteria is very suggestive, and would explain the rôle of infection in acute pancreatic necrosis. Another source may very easily be the intestinal canal, where permeability changes, probably due to bile-salts, would result in an invasion of bacteria into the peritoneal exudate, as postulated by Andrews.³⁴ Whether these experimental findings are applicable in man can be settled only by a routine and reliable bacteriological study of exudates found in acute pancreatic necrosis.

Thrombosis of the splenic vein and portal thrombosis have been found once each, but not in the same case. It is surprising that this complication does not occur more frequently, in the presence of such massive, and probably infected tissue destruction. Pleural empyæma was found once. Clinically, one sees not infrequently an immobility of the diaphragm, mostly on the left side, with a serous pleural exudate above it. This accompanies the retroperitoneal and subdiaphragmatic œdema, and through the extensive lymphatic connections through the diaphragm, may easily become infected. Together with subphrenic and perinephritic abscesses pleural empyæma must always be looked for as a complication of acute pancreatic necrosis.

General septicæmia was the cause of death in one case, originating in a diffuse purulent peritonitis. An adrenal hæmorrhage on the left side is noted once. Whether this occurred as an extension of a hæmorrhagic pancreatitis from the tail of the pancreas, or whether it occurred as a terminal phenomenon, cannot be determined from the record. It is, of course, known to occur in virulent infectious diseases with a fatal outcome, and could be clinically suspected by a hypoglycæmia.

DISCUSSION.—The Pre-operative Diagnosis.—The difficulty of diagnosis was best illustrated by Table IX, from which it would seem that a positive diagnosis has not been made (at least on the chart) in one single instance. As a routine procedure, not requiring much loss of time or special laboratory facilities, we would recommend the following measures in abdominal emergencies, when pancreatic necrosis is suspected.

(1) *Complete Blood Count.*—High red cell count and hemoglobin mean either dehydration, or, if the attack is hyperacute, gives the degree of shock. High white count rather speaks for acute localized inflammatory reaction; if it is unusually low, and rigidity is present, it is suggestive of peritonitis. High percentage of polymorphonuclear neutrophils signifies the virulence of acute infection. The Schilling-Arneth count will probably not be available

in most hospitals and can certainly not be counted on in emergencies during the night.

(2) *The urine specimen* contains albumen and casts in almost all acute abdominal cases, but the appearance of sugar is suggestive of pancreatic disease. However, it was only present in four out of twenty-two cases, and its absence is certainly not proof against pancreatic necrosis.

(3) *A Blood-sugar Determination.*—A high fasting blood sugar, according to the extensive studies of Krotoske³⁵ is present in acute pancreatic necrosis. Only a diffuse purulent peritonitis will give such high figures and if that can be eliminated with fair certainty the diagnosis of acute pancreatic necrosis is certain. The figures must be above 160 milligrams to be of any value as smaller elevations might be present with other acute suppurative conditions. We consider a blood-sugar reading, which can be taken by any of the newer micro methods, as the most important aid to a positive diagnosis.

(4) *The Determination of Diastase in Urine and Blood.*—Much has been written recently of the value of diastase determinations in acute pancreatic disease. We refer to only one comprehensive article by Skoog,³⁶ who made about 3,000 diastase determinations on acute abdominal cases. He determined urinary diastase and felt that while increased values may occur, although seldom, in other acute abdominal conditions, a negative finding, provided the determination is made within twenty-four to thirty-six hours after the onset of symptoms, *excludes any pancreatic pathology*. One of us, with Nathanson,³⁷ studied the rise in blood diastase following ligation of the tail of the pancreas. The original Wohlgemuth test,³⁸ modified for clinical purposes, is so simple to run that internes not trained in laboratory work can use it. It is far easier to determine than blood sugar. Because most clinical laboratories are unfamiliar with this test and its value in pancreatic disease, a brief description follows:

Ten cubic centimetres of blood are taken from a vein in a centrifuge tube, allowed to clot and gently centrifuged. Ten test tubes are set up in a rack. One cubic centimetre of serum (or urine) is pipetted into the first and second tubes. One cubic centimetre of 1 per cent. sodium chloride is pipetted into all ten test tubes. After proper mixing of serum and sodium chloride in tube 2, one cubic centimetre is pipetted over into tube 3. Here again, after proper mixing, one cubic centimetre is pipetted into tube 4 and so on up to the tenth tube. The last cubic centimetre pipetted out of the tenth tube is discarded. To every tube two cubic centimetres of a 0.1 per cent. soluble starch solution (Kahlbaum) are added, well mixed, and the whole rack of tubes incubated in a thermostat at 38° C. for thirty minutes. Thus the starch-splitting ferment of the blood can act on the starch solution. At the end of thirty minutes, the fermentation is abruptly stopped by immersion of the tubes in cold water for a few minutes. Three drops of a fiftieth normal iodine solution are added to each tube. The undigested amyloextrin gives a blue reaction, the erythroextrin red, and the achroextrin yellow. The end point is read at the tube which shows the first trace of purple without being a solid blue. Suppose this occurs in the fourth

tube. The quantity of diastase in the serum, which was able to digest starch up to that dilution, is calculated as follows: $D=2^4=16 \frac{38}{30}$ indicating at the same time the temperature and duration of the incubation. Values between 16 and 32 are normal with this technic. Following experimental duct ligation the diastase has risen to values between 1024 and 3072, which shows the enormous quantities of ferment that can be flooded into the blood-stream when external secretion is obstructed.

We are perfectly aware of the fact that the figures obtained in this manner could be made more accurate. The fact that the serum is incubated



FIG. 4.—Mr. E. C., aged forty-eight. Five days after onset of excruciating pain in upper abdomen, shock, cyanosis, no rigidity. On entrance to the hospital, this large gas bubble was found under the right diaphragm, above a fluid level. The subphrenic abscess was due to a perforation of an ulcer on the lesser curvature. Case of Drs. W. H. Nadler and G. de Takats.

only for thirty minutes and that the starch solution is not buffered to the optimal p_h of diastatic action (7.2) inhibits the action of the ferment. However, the rapidity and simplicity of the test described above makes it possible to use it anywhere, even in the middle of the night, provided the few necessary reagents are ready for use. It is, of course, possible, as Wohlgemuth more recently suggested,³⁹ to have a starch solution buffered with sodium phosphate to a p_h of 7.2 and to accelerate incubation to fifteen minutes by

using a water bath of 45° C., but we still feel that the test, as described above, serves the purpose of a rapid and adequately reliable orientation.

(5) *Röntgenological Examination.*—In spite of the valuable information that can be gained in obscure abdominal emergencies by films taken by portable X-ray apparatus, such examinations are not carried out often enough. Case,⁴⁰ since 1911, has repeatedly emphasized the value of such studies in acute intestinal obstructions, particularly those following operations. An opaque medium is not necessary and the patient is very little disturbed. Laurell⁴¹ has summarized his vast experience with the interpretation of flat films in intestinal obstruction, diffuse peritonitis and localized abscesses. Concerning acute pancreatic necrosis, he believes that a dilatation of the transverse colon and retroperitoneal thickening in the fatty tissue are suggestive, together with a sluggish diaphragm on the left side and exudates in the pleural cavity. A few spoonfuls of barium may bring out the changed contours of duodenal mucosa, and possibly duodenal displacement. Abscesses in the omental bursa can be well visualized.

We have no experience with the positive value of portable X-ray films in a case of acute pancreatic necrosis; however, as a method of excluding mechanical obstruction to the bowel, or gastroduodenal perforation with the characteristic subdiaphragmatic air bubble (Fig. 4) as emphasized by Schnitzler, Vaughan and Singer, its great value is obvious. It may also reveal the characteristic picture of localized peritoneal abscesses long before the clinical symptoms would permit of drainage.

To sum up our aids in pre-operative diagnosis: History of previous gall-bladder attacks, sudden sharp, excruciating pain in the epigastrium with frequent irradiation to the left, often nausea and vomiting, no rigidity, but definite tenderness in the epigastrium with ballooning out of the transverse colon, a marked cyanosis, blotchy and streaky in character. If the patient is in shock, the blood-pressure can hardly be taken. The pulse is empty. The temperature in the early cases is not elevated.

The blood count indicates the degree of dehydration and shock, the urine may contain sugar, but the blood sugar is high and so is the diastase content of the blood. The value of the test for diastase and a portable X-ray film are mainly important for their negative findings, whereby pancreatic necrosis can be excluded.

Pre-operative Management.—If the patient is in shock, as evidenced by the blood-pressure reading and the high red cell count, treatment should be instituted against shock. Small doses of morphine, heat, but chiefly a 6 per cent. gum-acacia solution intravenously will raise the blood-pressure very quickly. In cases of post-operative shock we know of no simpler and more efficient method. The purified gum-acacia solutions are kept in 100 cubic centimetre ampules, diluted to 500 cubic centimetres with normal salt and are free of all previous objections to impurities.⁴²

The rapid depletion of liver glycogen, the frequency with which liver damage is found at post-mortem, indicate the administration of dextrose and insulin. This should be given slowly, about 100 grams of dextrose in

10 per cent. solution, together with twenty to thirty units of insulin. Nothing should be administered by mouth, and if there is continuous nausea or repeated vomiting, a Rehfuß tube is passed and the stomach aspirated for retained gastric contents.

As discussed under the indications for operation, an early operation, if the patient is not in shock or has come out of shock, has a low mortality. However, most patients come to the surgeon after more than twenty-four hours have elapsed since the acute onset. If a positive diagnosis of acute necrosis can be made an expectant treatment can be instituted. About 3,000 cubic centimetres of fluid must be given daily; if the patient is obviously dehydrated, 4,000 cubic centimetres. Preferably dextrose-Ringer solution, or dextrose normal salt solution with about one unit of insulin to every three grams dextrose is used. Nothing is given by mouth. If there is considerable intestinal paralysis, twenty cubic centimetres of a 10 per cent. solution of sodium chloride will relieve distention. Under such a régime, even moribund patients may be revived and operations deferred to a later time. If patients die during this time with a peritonitis, an anuria or hepatic insufficiency, no operation could have saved them.

Surgical Procedures.—The anæsthesia is preferably gas-oxygen with local anæsthesia of the abdominal wall. Spinal anæsthesia, particularly in the early cases that may just have been in shock, does not seem advisable. The minimal amount of surgery should consist of draining the biliary tract by cholecystostomy and drainage of the omental bursa. A lumbar drainage through the left flank may be seriously considered, as Lotheisen⁴³ reports a mortality of 18 per cent. since the routine use of a lumbar drain. The mechanical conditions for drainage are more favorable and a post-operative ventral hernia may be thus avoided.

Post-operative Treatment.—Because of the possible injury to internal secretion, all patients should be watched for a decrease in sugar tolerance and suitable dietary restrictions or even insulin should be administered. The patient should be informed of a possibility of recurring attacks, particularly if the biliary-tract infection has not been radically attended to. In six months to a year following complete closure of the wound, a cholecystectomy, and, if necessary, common-duct drainage should be advised and at the same time the incisional hernia, which almost invariably follows pancreatic drainage, can be attended to. Disturbances of external pancreatic secretion can be ameliorated by potent pancreatic extracts given orally. In patients who develop a late pseudo-cyst or a sclerosis of the pancreas, further surgical procedures must be advised.

Summary.—Thirty cases of acute pancreatic necrosis or their sequelæ have been discussed. The uncertainty of pre-operative diagnosis and the high mortality challenge to further efforts in this field. A routine use of blood-sugar and blood-diastase determinations together with a frequent employment of flat X-ray plates may greatly improve our diagnostic ability. The proper time of operation and the selection of the proper surgical methods will diminish mortality. Attention should be focused to late sequelæ of acute

pancreatic necrosis, some of which can be prevented. A prophylaxis of acute pancreatic necrosis for the large majority of cases lies in early surgical treatment of biliary-tract infection.

We wish to express our deep gratitude to the staffs of Evanston and Wesley Memorial Hospitals and particularly to Drs. Charles A. Elliott, William R. Parkes and Harry M. Richter for the privilege of obtaining follow-up records of their patients.

BIBLIOGRAPHY

- ¹ Körte, W.: Die chirurgischen Krankheiten und die Verletzungen des Pankreas. Deutsch. Chirurgie, vol. xlv, Gustav Enke, Jena, 1898.
- ² Heiberg, K. A.: Die Krankheiten des Pankreas. J. F. Bergmann, Wiesbaden, 1914.
- ³ Gross, O., and Guleke, N.: Die Erkrankungen des Pankreas. Julius Springer, Berlin, 1924.
- ⁴ Schmieden, V., and Sebening, W.: Surgery of the Pancreas. Surg., Gyn., and Obst., vol. xlv, pp. 735-751, 1928.
- ⁵ Wolfer, John A.: Acute Pancreatitis. Intern. Surg. Digest, vol. vii, No. 4, W. F. Prior Co., Hagerstown, Maryland.
- ⁶ Heller, E.: Fortschritte, der Pankreaschirurgie. Zblatt f. Chir., vol. lvii, pp. 1667-1685, 1930.
- ⁷ Cit. Eliason, E. L., and North, J. P.: Acute Pancreatitis. Surg., Gyn., and Obst., vol. li, pp. 133-189, August, 1930.
- ⁸ Cit. Bergmann, von G.: Internistisches Korreferat zur Chirurgie des Pankreas. Arch. f. klin. Chir., vol. cxlviii, pp. 388-397, 1927.
- ⁹ Wolfer, John A.: The Role of Pancreatic Juice in the Production of Gallbladder Disease. Surg., Gyn., and Obst., vol. liii, pp. 433-447, October, 1931.
- ¹⁰ Wolfer, John A.: Personal Communication.
- ¹¹ Doré, G. R.: The Urinary Syndrome in Bilious Pneumonia Arch. d. malad d. reins et d'organes gen. urin., vol. vi, pp. 20-29, 1931.
- ¹² Helwig, F. L., and Orr, Th. G.: Traumatic Necrosis of the Liver with Extensive Retention of Creatinine and High-grade Nephrosis. Arch. Surg., vol. xxiv, pp. 136-144, January, 1932.
- ¹³ Cannon, Walter B.: Traumatic Shock. D. Appleton and Co., New York and London, 1923.
- ¹⁴ Garrey, W. E.: The Basal Leucocyte Count and Physiologic Leucocytosis. Proc. Staff Meetings, The Mayo Clinic, vol. iv, pp. 157-159, 1929.
- ¹⁵ Bringmann, K.: Die Diagnose der akuten Pankreasnekrose mit besonderer Berücksichtigung des Blutbildes. Deutsch. Zeitsch. f. Chir., vol. clxxv, pp. 211-229, 1924.
- ¹⁶ Roseno, A., and Dreyfuss, W.: Diagnostisches zur akuten Pankreatitis. Deutsch. med. Wochsch., vol. liv, pp. 783-784, 1928.
- ¹⁷ Schilling, V.: Das Blutbild und seine klinische Verwertung. 2 Auflage Gustav Fischer, Jena, 1922.
- ¹⁸ Case, James T.: Roentgen Observations of the Duodenum with Special Reference to Lesions of the First Portion. Am. Jour. of Roentgenology, vol. iii, p. 314, June, 1916.
- ¹⁹ Archibald, E.: The Experimental Production of Pancreatitis in Animals as a Result of the Resistance of the Common-duct Sphincter. Surg., Gyn., and Obst., vol. xxviii, pp. 529-545, 1919.
- ²⁰ Nordmann, O.: Akute Pankreasnekrose und Cholecystitis. Chirurg., vol. i, pp. 721-726, 1929.
- ²¹ Orr, Thomas G.: The Action of Sodium Chloride on the Small Intestine. Ann. Surg., vol. xciv, pp. 732-737, 1931.
- ²² Nicolaus, H.: Akute Pancreatitis, ihre Behandlung und Dauererfolge. Beitr. z. klin. Chir., vol. clii, pp. 351-368, 1931.

- ²³ Walzel, P.: Discussion of Schmieden's Paper. Arch. f. klin. Chir., vol. cxlviii, pp. 67-68, 1927.
- ²⁴ Whipple, A. O.: Pancreatic Asthenia. Ann. Surg., vol. lxxviii, pp. 176-184, 1923.
- ²⁵ Schmieden, V., and Voss, O.: Parotitis und Pancreatitis, zwei wesensverwandte Krankheiten. Zblatt f. Chir., vol. lvii, pp. 1017-1023, April 26, 1930.
- ²⁶ Henschen, C.: Die akuten subakuten und chronischen Schwellungskrisen der Leber. Arch. f. klin. Chir., vol. clxvii, pp. 825-905, April, 1931.
- ²⁷ Hohlbaum, J.: Discussion on Schmieden's paper. Arch. f. clin. Chir., vol. cxlviii, pp. 75-76, 1927.
- ²⁸ Payr, E., und Martina, F.: Experimentelle Untersuchungen ueber die Actiologie der Fettgewebsnekrose und Leberveränderungen bei Schädigung des Pankreasgewebes. Deutsch. Zschr. f. Chir., vol. lxxxiii, p. 189, 1906.
- ²⁹ Bernhard, F.: Das Auftreten des Diabetes mellitus nach akuten Pankreaserkrankungen. Klin. Wochschr., vol. x, pp. 632-637, 1931.
- ³⁰ de Takats, Geza: Ligation of the Tail of the Pancreas in Juvenile Diabetes. Endocrinology, vol. xiv, pp. 255-264, 1930.
- ³¹ Walzel, P.: Ueber des Symptom der fleckigen und gitterförmigen Cyanose bei akuter Pankreasnekrose. Wien klin. Wochschr., vol. xl, p. 218, 1927.
- ³² Discussion on Schmieden's Paper. Arch. f. klin. Chir., vol. cxlviii, pp. 72-73, 1927.
- ³³ Dragsted, L.: The Toxicity of the Products of Pancreatic and Gastric Digestion. Proc. Soc. Exp. Biol. Med., vol. xxix, p. 216, November, 1931.
- ³⁴ Andrews, E., Rewbridge, A. B., and Hrdina, J.: Causation of *B. Welchii* Infection in Dogs by Injection of Sterile Liver Extracts of Bile Salts. Surg., Gyn., and Obst., vol. liii, pp. 176-181, 1931.
- ³⁵ Krotoske, Jean: Examen du metabolisme des hydrates du carbon et sa valeur dans les affections chirurgicales du pancreas. Chir. Clin. Polonica, vol. ii, p. 166, 1931.
- ³⁶ Skoog, T.: Diastase-untersuchungen im Harn bei akuten Erkrankungen der Bauchhöhle. Chirurg., vol. i, pp. 305-312, 312, 1929.
- ³⁷ de Takats, G., and Nathanson, I. T.: The Effect of Ligation of the Tail of the Pancreas on Diastase in the Blood. Arch. Surg., vol. xix, pp. 788-793, November, 1929.
- ³⁸ Wohlgemuth, L.: Das Verhalten der Diastase im Blut. Bioch. Zeitschr., vol. xxi, p. 381, 1909.
- ³⁹ Wohlgemuth, J.: Zur Diagnostik der Pankreasgewebsnekrose mittels der Diastasebestimmung im Urin. Klin. Wochschr., vol. viii, pp. 1253-1254, July 2, 1929.
- ⁴⁰ Case, James T.: Roentgenological Aid in the Diagnosis of Ileus. Am. Jour. of Roentgenology, vol. xix, p. 413, 1927.
- ⁴¹ Laurell, H.: Roentgenbefunde bei akuten Erkrankungen der Bauchhöhle. Chirurg., vol. ii, pp. 422-434, 1930.
- ⁴² Keith, N. M.: Intravenous Medication. Jour. Am. Med. Assn., vol. xciii, pp. 1517-1522, November 16, 1929.
- ⁴³ Lotheisen, G.: Discussion on Schmieden's Paper. Arch. f. klin. Chir., vol. cxlviii, p. 83, 1927.

CHRONIC INTERLOBULAR PANCREATITIS

By J. WILLIAM HINTON, M.D.

OF NEW YORK, N. Y.

FROM THE FOURTH MEDICAL AND SURGICAL DIVISION OF BELLEVUE HOSPITAL

THE pancreas is the only intra-abdominal organ that produces symptoms of a chronic surgical nature that physical examination, röntgenologic or laboratory studies will not aid in establishing a diagnosis except by negative findings. Of course, when the Islands of Langerhans are diseased we have glycosuria and hyperglycæmia, but chronic infection of the pancreas rarely gives evidence of disturbed carbohydrate metabolism. In considering chronic pancreatitis it is essential to understand the histologic picture of the normal organ which is illustrated in Fig. 1, and one will then have a clearer conception of chronic interlobular pancreatitis. I have studied⁶ sections from the pancreas in sixty-six cases to determine whether chronic pancreatitis is a relatively frequent disease. Of these cases fifty were taken from people meeting with accidental death and sixteen from people with acute peritonitis from different causes, and in none was there evidence of chronic pancreatitis.

Etiology.—Chronic pancreatitis is divided into two forms: first, chronic interlobular pancreatitis; and second, chronic interacinar pancreatitis. The interlobular type results from bacteriologic infection of the connective tissue lying between the lobules and it is the one that interests us in this paper. The interacinar pancreatitis is the result of arteriosclerotic changes and is usually associated with diabetes and this bears little or no relation to infection, while chronic interlobular pancreatitis rarely involves the lobules. How infection reaches the pancreas in the chronic type of disease has not been settled, but there is considerable debate as to whether it ascends the ducts, is of a lymphatic origin, or is produced by direct extension from an associated disease, such as duodenal ulcer. Archibald,¹ in 1913, in a paper entitled "A New Factor in the Causation of Pancreatitis" reported thirty-six cases of pancreatitis in 60 per cent. of which gall-stones were absent. He attributes the pancreatitis to a spasm of the sphincter of Oddi at the ampulla, which results in bile entering the pancreatic ducts. Mann and Giordano,⁹ working experimentally on goats, doubly ligated the common bile-duct and divided it at its entrance into the duodenum. The animals lived from one to thirty days. In none was there either macroscopically or microscopically an area with the appearance of acute hæmorrhagic pancreatitis. The results of these experiments emphasize: first, that with the pancreatic duct emptying directly into the common bile-duct and the latter completely obstructed, bile was not forced into the pancreas except after a considerable length of time. Second, that bile did pass into the pan-

creatic duct and infiltrated the pancreas completely when under the maximum of pressure which the physiologic mechanism of the animal could produce, but acute hæmorrhagic pancreatitis was not seen.

Sweet,¹¹ in working experimentally on dogs, has been able to remove a portion of the pancreas and join the head of the pancreas or the duct to the intestine without danger of pancreatitis, either acute or chronic, for as long as an eleven months' interval. From these experiments it would seem that infection rarely ascends the ducts in animals. This may be an explanation for some cases of chronic pancreatitis in humans, but it seems doubtful whether it is the most common cause.

The lymphatic origin of the disease has an abundance of clinical data to support such a contention. Deaver and Pfeiffer³ report a series of fifty-two cases of chronic pancreatitis in which the head alone was affected in

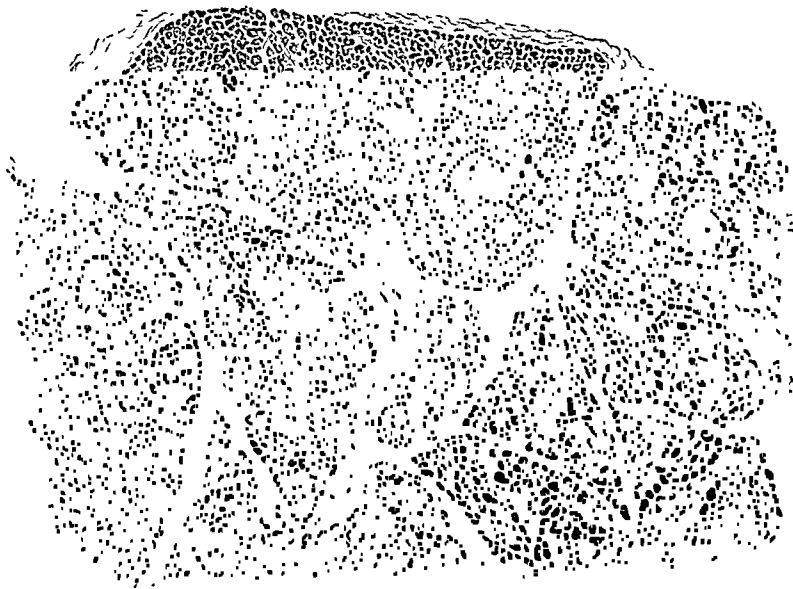


FIG. 1.—Reproduction from Piersol's Histology showing the gland divided into lobules with the interlobular connective tissue.

forty-two and in only nine was the tail involved. In twenty-seven cases there was well-marked evidence of involvement of the lymph-nodes in the neighborhood of the head of the pancreas. They found the infection localized chiefly in the triangle of the pancreatic infection, between the duodenum and converging ducts of Santorini and Wirsung. They attribute the chronic infection to lymphatic origin. If the infection ascends the pancreatic ducts, the induration should be more general. The lymphatics from the gall-bladder drain only to the triangle of pancreatic inflammation, as has been demonstrated by Franke.⁵ Of the seventy-nine patients with chronic pancreatitis at the Lankenau Hospital reported by Deaver, seventy-two or 91 per cent. showed evidence of biliary infection, while forty-two or 53 per cent. had calculi.

The following cases will illustrate that chronic interlobular pancreatitis is frequently produced by direct extension from duodenal ulcers.

CHRONIC INTERLOBULAR PANCREATITIS

CASE I.—Male, aged fifty-two years, admitted to the Fourth Surgical Division, Bellevue Hospital, January 26, 1928, having previously been operated upon in another hospital in Greater New York on December 15, 1927. The patient on admission was jaundiced and complained of severe abdominal pain and was receiving morphine grains $\frac{1}{6}$, t. i. d. A résumé of the operative findings from the other institution was carcinoma of the head of the pancreas with metastasis to the spine. In view of this diagnosis it was thought advisable to do a gastro-intestinal series to demonstrate the pancreatic tumor, but the patient was found to have a duodenal ulcer from the röntgenologic findings. The patient was put on a Sippy diet and within one week was greatly improved and was taken off morphine, and discharged from the hospital February 12, 1928. He was followed in the Gastro-Enterological Clinic until April 23, when he was readmitted, due to the fact he had been having severe pain for two weeks, but previous to this he had been symptomatically well for two months. Dr. John H. Morris operated upon the patient April 26 and an ulcer was found in the second portion of the duodenum with a large induration of the head of the pancreas the size of a large lemon. A gastro-enterostomy was done, the gall-bladder found normal, the appendix was not removed. The patient has been followed regularly since the operation and has had no complaints referable to his stomach and is symptomatically well.

CASE II.—Male, aged fifty-two years, admitted to the Gastro-Enterological Clinic of the Fourth Medical and Surgical Divisions at Bellevue Hospital January 12, 1929, with a röntgenologic diagnosis of pyloric ulcer. Patient was put on a Sippy diet. He was symptomatically well until September 28, and became X-ray negative June 14. He was also negative October 3. After his symptoms returned the pain could not be relieved by conservative treatment, although his gastro-intestinal series were negative. He was then admitted to the hospital and was operated upon by me November 9, 1929. On opening the abdomen the gall-bladder was found normal, the duodenum was mobile and easily inspected, no evidence of an ulcer was found on the anterior surface but a slightly indurated area was felt posteriorly, and the head of the pancreas was the size of a lemon. A posterior gastroenterostomy was done, and also an appendectomy. The patient made an uneventful recovery. He has been followed regularly in the clinic since that time and has remained symptomatically well and X-ray negative.

CASE III.—Male, aged fifty-seven, seen first January 16, 1931, with a history of a duodenal ulcer for eighteen years. He had been under the care of Dr. Arthur F. Chace for the past fourteen years. He did very well on medical treatment until two years before seen by me. His pain had increased gradually during the previous two years and he did not get relief from diets. The pain was intense enough to keep him awake several hours at night and during the past three months it had increased in severity. A gastro-intestinal series on January 10, by Dr. I. Seth Hirsh, revealed a healed duodenal ulcer and the gall-bladder negative. Doctor Chace felt that this patient should be operated upon and he was referred for same, the pre-operative diagnosis being chronic pancreatitis and duodenal ulcer. At operation the patient was found to have an ulcer in the second portion of the duodenum and the duodenum was adherent to the pancreas, which was the size of a lemon. A posterior gastroenterostomy and an appendectomy were done and the patient has been symptom-free for the past six months.

These cases, besides six others with duodenal ulcers and chronic pancreatitis whom I have seen, will illustrate that chronic pancreatitis may arise by direct extension from associated infections.

From the above data it would seem that the gall-bladder and biliary system are the primary factors in producing chronic infection of the pancreas. Ulcers of the duodenum probably play the second most important rôle, while the appendix and ileocecal angle have direct lymphatic drainage to the head of the pancreas.

Signs and Symptoms.—We are referring to acute exacerbations of upper abdominal pain that occurs in patients following cholecystectomies, or in patients suffering from gastric or duodenal ulcers who have not been operated upon. Pain is the chief complaint of the patient and the individual is usually seized with a severe upper abdominal pain which is constant in character. It is difficult for these patients to localize the pain but occasionally they say it is in the right upper quadrant and radiates to the back. More frequently they state the pain is on the left side in the region of the left kidney, and due to its location on the left side it would make one suspect a renal calculus. The intensity of the pain will vary in different individuals, presumably depending upon the severity of the pancreatic involvement. These attacks may last from a few hours to forty-eight or seventy-two hours. If the pain is located in the left kidney region at the beginning of the attack, it quite frequently localizes itself in the upper abdomen in the middle of the epigastrium after forty-eight hours or so. The patients usually feel normal within a few hours after the pain subsides. Nausea is not commonly seen in this condition. Vomiting is usually encountered and it comes on approximately within the first hour of pain and usually persists during the attacks. The vomitus is clear or slightly bile-tinged and non-offensive. Because of the persistent vomiting and the sudden and severe abdominal pain, one often suspects a high intestinal obstruction, but the general appearance of the patient is not that of one suffering from an intestinal obstruction, and in spite of the great pain and persistent vomiting the general condition does not indicate that the patient is critically ill. Jaundice is quite frequently encountered in the severe cases, particularly after they have been incapacitated for forty-eight or seventy-two hours. This is presumably due to a compression of the bile duct as a result of the swelling of the head of the pancreas. According to Helly⁷ the common duct passes through the head of the pancreas in approximately 62 per cent. of cases. Mayo Robson¹⁰ believes that some of the cases of catarrhal jaundice may be due to a mild pancreatitis.

On physical examination the abdomen is usually not distended and does not have any marked rigidity, but the patient complains of indefinite tenderness over both upper quadrants and frequently in the costovertebral angle, more frequently on the left side than the right. Eggers⁴ was impressed with the lack of physical signs as compared with the severity of the symptoms in his cases. In two of his patients the house staff ventured to state that they were simply neurotic. The temperature is usually normal, but when elevated it is around 100° F. The blood examination, in the milder cases, will reveal a normal leucocyte count or only a very slight increase in the total count, as well as the polymorphonuclear leucocytes. The urine analysis is negative.

The diagnosis of this condition can be made only by the process of elimination. One must exclude renal calculi and bear in mind the possibility of a stone in the common duct which was overlooked at the original operation. In the severe forms of this condition it is sometimes impossible to

make a diagnosis without an exploratory laparotomy. In the milder types of infection one should suspect the pancreas as the cause of trouble and keep the patient under observation. In Judd and Burden's⁸ series, the findings after an exploratory laparotomy were pancreatitis in seventeen out of twenty-four cases, and the common bile-duct was patent in all. Aub and his co-workers² have stated, in a recent publication, that 20 cubic centimetres of 5 per cent. solution of calcium chloride administered intravenously will give immediate relief in lead colic and biliary or renal colic, but if the pain is due to cholecystitis without stones, or ulcers of the stomach or duodenum, it is only partly effectual in relieving pain. In view of their observations it would seem that calcium chloride should be of definite value in differentiating between a stone in the common duct and chronic pancreatitis.

Treatment.—A patient suffering from a chronic pancreatitis associated with an ulcer of the stomach or duodenum offers a very excellent prognosis if the ulcer is operated upon. Usually a gastroenterostomy will suffice to give such a patient a symptomatic cure. The seven cases that have been operated upon and are now being followed in the Gastro-Enterological Clinic of the Fourth Medical and Surgical Divisions of Bellevue Hospital are symptomatically well, the longest period since operation being three and a quarter years and the shortest nine months. I have also two cases operated upon in private practice, six or eight months ago, that are symptomatically well. In patients that have had previous laparotomies for cholecystitis and cholelithiasis usually in due course of time, meaning from one to three years, they outgrow their symptoms if a cholecystectomy was done at the original operation as the pancreatic infection in this instance is secondary to the gall-bladder disease which has been removed, and the infection in the pancreas will then subside. Conservative treatment in this type of patient should be employed as further exploration is of no value and probably introduces additional infection.

Comment.—The "flare-up" of symptoms of a chronic pancreatis can be compared to the acute exacerbations of chronic osteomyelitis, meaning that the organ is diseased and unless the primary focus is operated upon the pancreatic infection will become more extensive and even after operations on the biliary tract these exacerbations will occur, which is one reason for not allowing a patient to go over a prolonged period with a chronic cholecystitis that does not respond to medical treatment. The chronic infections and the acute exacerbation of these are an entirely different pathologic process from acute hæmorrhagic pancreatitis which demands immediate operation. The history in the hæmorrhagic type is a very sudden onset of upper abdominal pain that is not relieved by morphine, with a board-like abdomen and a moderately elevated temperature of 101° F. to 102° F., and a slightly elevated leucocyte count of from ten to twelve thousand and an extremely high polymorphonuclear count of around 95 per cent. These findings can

be compared with those found in the chronic disease and one should be able to make a differential diagnosis between the two.

BIBLIOGRAPHY

- ¹Archibald, E. A.: A New Factor in the Causation of Pancreatitis. *Internat. Cong. Med.*, Sect. 12, Surgery, vol. xvii, p. 21, 1913.
- ²Bauer, Walter, Salter, W. T., and Aub, J. C.: Calcium and Phosphorus Metabolism. *A. M. A.*, April 11, 1931.
- ³Deaver, and Pfeiffer: *ANNALS OF SURGERY*, vol. lviii, p. 151, 1913.
- ⁴Eggers, Carl: Acute Pancreatitis. *ANNALS OF SURGERY*, vol. lxxx, pp. 193-209, 1924.
- ⁵Franke: *Deutsche Ztschr. f. Chir.*, Sept., 1911.
- ⁶Hinton, J. William: Chronic Pancreatitis in Routine Necropsy Examination. *ANNALS OF SURGERY*, April, 1928.
- ⁷Helly: *Arch. f. Mikroskop. Anat.*, lii, p. 773, vol. liii, 1898.
- ⁸Judd, E. Starr, and Burden, Verne: Non-Calculous Intermittent Biliary Obstruction following Cholecystectomy. *ANNALS OF SURGERY*, vol. lxxix, pp. 533-537, 1924.
- ⁹Mann, Frank C., and Giordano, Alfred S.: *Arch. Surg.*, vol. vi, pp. 1-30, 1923.
- ¹⁰Robson, Mayo: Pancreatic Catarrh and Interstitial Pancreatitis in Their Relation to Catarrhal Jaundice and Also to Glycosuria.
- ¹¹Sweet, J. E.: *The Surgery of the Pancreas*. J. B. Lippincott Co., Philadelphia.

POST-OPERATIVE SHOCK FOLLOWING SPLENECTOMY FOR CHRONIC THROMBOCYTOPENIC PURPURA

BY RICHARD LEWISOHN, M.D.

OF NEW YORK, N. Y.

FROM THE SURGICAL SERVICE OF MOUNT SINAI HOSPITAL

IN THIS brief report I wish to draw attention to the rather frequent occurrence of post-operative shock following splenectomy for chronic thrombocytopenic purpura. I do not think that attention has hitherto been directed to the importance of this picture.

Before discussing the clinical picture I would like to present the histories of three personal cases of thrombocytopenic purpura which suffered from severe post-operative shock following splenectomy and which form the basis of this report.

CASE I.—No. 262347. J. C., male, aged fifteen, admitted December 21, 1925, discharged February 11, 1926. Bleeding tendency first noticed about three years ago. For the past two years he has suffered from epistaxis. Following a tooth extraction he bled for twelve hours. No purpuric spots were noted on the skin. Hæmoglobin 83 per cent., red blood cells, 5,508,000, platelets 52,000; bleeding time three and one-half minutes, coagulation time five and one-half minutes. Tourniquet test negative within five minutes. No clot retraction within twenty-four hours. In the inside of the mouth and cheeks there are several petechiæ. Another rather large spot is noticed in the neighborhood of the tourniquet test. Four days after admission he bled profusely from the buccal mucous membrane and from his lips. There are many petechiæ now on the soft and hard palates. Hæmoglobin during time of observation had fallen from 83 per cent. to 68 per cent. *Diagnosis*.—Thrombocytopenic purpura.

Splenectomy was performed January 16, 1926, under general anæsthesia. A left upper quadrant oblique incision was made parallel to the costal margin. The spleen was found enlarged, adherent to the stomach but free on the parietal surface. The adhesions were divided. The gastro-lienal ligament was clamped and divided. The pedicle of the spleen was very short; it was divided between clamps, and the spleen was removed. A rubber tube was put into the subphrenic space. The abdomen was closed in layers. The patient returned to the ward in good condition. One-half hour later he suddenly went into deep collapse; the color was extremely pale, extremities and face were cold and clammy. Patient was extremely restless. A venous infusion of 500 cubic centimetres was given; this procedure was repeated three hours later. His condition improved during the evening and he recovered from the shock about eight hours after the operation. He made a good recovery and when seen recently was in perfect condition.

CASE II.—No. 314225. B. M., female, aged thirty, admitted May 12, 1930, died May 15, 1930. History of having developed ecchymoses on the skin very easily for the last fifteen years. Severe symptoms had been present for only two years, consisting of large ecchymoses, severe epistaxis, intra-oral bleeding, metrorrhagia, and menorrhagia. This had been accompanied by headaches and nausea. Physical examination revealed the entire body to be covered by fine purpuric spots. In addition, there were several large ecchymotic areas. The spleen was palpable, but not markedly enlarged. A diagnosis of thrombocytopenic purpura hæmorrhagica was made and confirmed by blood findings. Red, white, and differential counts were normal, platelets

1,900, bleeding time twenty-five minutes, coagulation time fifteen minutes, the clot did not retract; tourniquet test was strongly positive.

Patient was transferred to the Surgical Service and splenectomy performed under general anæsthesia. The spleen was slightly enlarged. The lienophrenic ligament and a few adhesions had to be divided bluntly before it could be delivered. After ligation of the pedicle and after removal of the spleen, the operative field appeared dry. The abdomen was closed without drainage. About thirty minutes after the patient's return to the ward she went into profound shock. An intravenous infusion was given immediately, followed by a blood transfusion (500 cubic centimetres of citrated blood) about two hours later. Blood transfusion caused no great change for the better, and though an exploratory puncture in the right lower quadrant yielded no blood, it was thought that the possibility of bleeding was sufficiently great to justify exploration. The patient was taken back to the operating room. The wound was re-opened and a small amount of blood was found. The pedicle was dry, but blood had collected under the diaphragm, probably originating there from the division of the adhesions. Clots were evacuated and the subphrenic space was packed. The wound was closed again; one rubber tube being inserted. Another transfusion was given at once. Following this revision the general condition improved. Temperature mounted, however, and the patient was troubled by some abdominal distention and regurgitation of the stomach contents. To maintain fluids an intravenous infusion was ordered on the second day after the operation. During this she had a severe chill with rise of temperature to 106°, pulse became rapid and thready, patient cyanotic and bathed in sweat. Intravenous infusion was promptly discontinued. Death ensued a few hours later.

Blood count on the day of the exitus showed: platelets 375,000, bleeding time three minutes, leucocytes 15,600 with 90 per cent. polymorphonuclears.

Post-mortem examination showed a localized fibro-purulent peritonitis, moderate hæmorrhage into the peritoneal cavity, pulmonary œdema, ecchymosis of endocardium, bladder, and skin.

Epicrisis.—The re-laparotomy for suspected hæmorrhage was an error in judgment. Though a fair amount of fluid blood and clots were encountered, a free hæmorrhage was absent. The patient succumbed to localized infection.

CASE III.—No. 321568. D. A., male, aged fourteen, admitted December 27, 1930, discharged February 15, 1931. History of bleeding gums, purpuric blotches, and repeated epistaxis for several years. On admission physical examination showed clotted blood in the nostrils, purpuric blotches, petechiæ, conjunctival hæmorrhages, palpable liver and spleen. Hæmoglobin 94 per cent., red blood cells 5,000,000, white blood cells 12,650 with 74 per cent. polymorphonuclears, platelets 40,000, bleeding time one hour and thirty-five minutes, clotting time two minutes, tourniquet test positive. He was transferred to the Surgical Service where just before operation his hæmoglobin was 82 per cent., bleeding time thirty-eight minutes, platelet count 80,000. Splenectomy was performed under general anæsthesia through an incision along the left costal margin.

The spleen was slightly enlarged without any adhesions. The patient left the operating room in excellent condition. Twenty minutes after he had reached the ward he suddenly went into a profound shock, became pulseless and ice cold, very restless and uncontrollable. An intravenous infusion was given immediately followed by 500 cubic centimetres of citrated blood taken from a donor, who was in the hospital during the operation and was kept in the reception ward to be available for immediate use, in case of sudden post-operative shock. Immediately following this transfusion, patient's pulse improved and condition became better during the evening. Air hunger, which had been observed before the transfusion, disappeared. The next morning his condition was excellent. About five days after operation he vomited a pus basin full of fresh blood. However, his pulse did not change very much and the circulation was very good.

Another transfusion was given following this hæmorrhage and the patient made a good recovery.

Two cases with a similar post-operative course of shock following splenectomy for chronic thrombocytopenic purpura are herewith given in abstract. They were operated by two of my colleagues at the hospital.

CASE IV.—No. 282556, 1927. Thirteen-year-old girl. Splenectomy in typical fashion. Upon return to her room the child was conscious, pulse good. Thirty minutes later the condition was very poor; the pulse was very weak. Two hours later the child went into shock; pulse could not be obtained. Though an immediate blood transfusion was ordered, the child died before arrival of the donor.

CASE V.—No. 294773, 1928. Patient was returned from operating room at 10.30 A.M. During the evening the pulse became very weak and irregular. She was put into shock position and received a Murphy infusion. The condition did not improve during the night. The next day pulse was still imperceptible at times, the body was cold and clammy. In the afternoon of the second day a blood transfusion was given. General condition improved immediately after the transfusion and the patient made an uneventful recovery.

In looking over the records of splenectomies performed at this hospital from 1926 to 1930 inclusive I was struck by the fact that whereas deep post-operative shock followed splenectomy for chronic thrombocytopenic purpura in five out of nineteen cases, a similar condition was not observed among seventeen splenectomies performed during this period for other causes.

The two deaths in this series probably could have been avoided, one case (II) if the proper diagnosis of shock instead of hæmorrhage had been made, the other case (IV) if an immediate transfusion had been given.

The sequel of events usually occurs in the following manner: the patient leaves the operating room in perfect condition. Respiration and circulation are normal. Either within an hour or a few hours after the operation the patient suddenly goes into deep collapse. The pulse is imperceptible, the skin is cold and clammy, the patient is very restless.

In the five cases reported above, the operations were of short duration and did not offer technical difficulties. The patients appeared to be good operative risks. While in this group of cases the post-operative shock usually occurs very soon after the end of the operation, delayed shock (six to twelve hours post-operative) may follow the splenectomy (Case V).

It is interesting to note that in Case V the post-operative shock lasted for twenty-four hours in spite of supportive measures. The serious clinical picture changed immediately after the blood transfusion.

Chronic thrombocytopenic purpura is at present the most frequent indication for splenectomy. For instance in this hospital more splenectomies were performed for this disease between 1926 and 1930 inclusive than for all other splenic diseases combined (19:17). As a rule post-operative and late results of splenectomy in this group of cases are excellent. For this reason it seems of some importance to point out the frequency of post-operative shock which may follow splenectomy for chronic thrombocytopenic purpura

(26 per cent. of our material). Properly timed blood transfusion may overcome this alarming emergency.

CONCLUSIONS

(1) For some unknown reason sudden post-operative shock seems to follow splenectomy for chronic thrombocytopenic purpura in a large percentage of cases. This observation is of practical importance, as shock and hæmorrhage are apt to give practically identical clinical pictures.

(2) Blood transfusion is the best method to combat post-operative shock following splenectomy.

(3) A properly tested donor ought to be present in the hospital at the time of operation for use in an emergency. The donor should be kept in the hospital for at least twelve hours, as late shock may follow.

THE ETIOLOGY OF INFLAMMATORY AND DEGENERATIVE DISEASES OF THE APPENDIX*

BY BERNHARD STEINBERG, M.D.

OF TOLEDO, OHIO

OUR knowledge of the etiology and prophylaxis of appendicitis is in the state it was in the later days of its clinical recognition by Reginald Fitz (1886), McBurney (1889), and Fowler (1894). At the present, our sentiment to appendicitis is much like that to the communicable diseases of childhood a few years ago. The sooner we have it the better off we are.

There are two diametrically opposed views in regard to the origin of appendicitis: (1) A circulatory disturbance of the appendiceal blood-vessels produces a necrosis or inflammation (Ricker,¹ Rosenow,² Portis³); and (2) the enterogenic theory which assumes that the disease arises from within the lumen of the appendix (Aschoff,⁴ Heile,⁵ Bowen,⁶ Gross,⁷ Niedermeyer⁸). All these authors, although adhering to the general conception, have different views of the mechanism that results in appendicitis. Aschoff believes that retention with a prolonged contact of the mucosa with pathogenic bacteria results in inflammation. Heile thinks that there is a trypsinic action of an abnormal amount of fluid in the lumen of the appendix with a consequent necrosis of mucosa assisted by the appendiceal bacteria. Gross implicates inspissated fecal material and Niedermeyer thinks that foreign bodies in the lumen are responsible for the lesion. The enterogenic school stimulated a number of analyses of the appendiceal bacterial flora (Isabolinsky,⁹ Bagger and Mikkelsen,¹⁰ and Warren¹¹). These investigations demonstrated that the bacterial flora are varied, numerous, and that no single organism could be held responsible.

Another controversial topic is that of chronic appendicitis. Clinically, it is a more or less definite entity, but the pathologists are unable to agree to the criteria that constitute this condition. Among many theories of the etiology, Aschoff's¹² conception that chronic appendicitis is an end-result of an acute attack is probably the most widely accepted. Portis advances the interesting hypothesis of an interference with the blood supply due to adhesions and kinking. He does not believe that chronic appendicitis is an inflammatory condition.

Separation of the Retrogressive and the Degenerative from the Inflammatory Lesions of the Appendix.—In a survey of surgically removed appendices I found that 44 per cent. of them were free of an inflammatory lesion (exclusive of normal appendices). The patients' histories and their condition one year or more after the appendectomy demonstrated, however, that the appendix must have been involved. A study of the 44 per cent. of the

* From the Department of Medical Research of the Toledo Hospital.

appendices disclosed definite abnormalities. These abnormal changes consisted either of mucosal erosions or of an atrophy of the appendiceal wall. The pathological changes in greater detail had been described by me elsewhere.¹³ It was evident that, though an inflammatory process did not exist, other types of abnormal structural alterations of the appendix may give rise to clinical manifestations. Since the introduction of the term appendicitis by Reginald Fitz, we have been constantly thinking of all conditions referable to the appendix in terms of inflammation. The pathologist even stretches the definition of inflammation to accommodate changes in the appendix which he can not classify but which he appreciates to be abnormal.

Since the appendices could be separated into two groups (inflammatory and non-inflammatory) pathologically, a study of the patients' histories was made to determine whether a similar differentiation could be achieved clinically. It was found, that with a few exceptions, those histories could be likewise placed into two groups: One corresponded to the pathologically inflammatory class and the other to the retrogressive and the degenerative. The term appendicitis denotes inflammation and does not depict the retrogressive and the degenerative types of appendiceal lesions. The prognosis of the two groups vary. In order to convey this distinct difference between the two types of appendiceal disease I introduced¹³ the term appendicosis for the retrogressive and the degenerative group. The clinical differentiation of the two groups is as follows:

Clinical Manifestations of

Appendicosis

- (1) Single attack, intermittent attacks or continuous discomfort.
- (2) Pain is dull and not severe.
- (1) Single attack, intermittent attacks or the right iliac fossa at the beginning or throughout the attack.
- (4) Nausea slight and frequently absent, vomiting rare.
- (5) No rigidity or muscle spasm. Soreness on deep palpation over the right iliac fossa.
- (6) No fever and no leucocytosis.
- (7) In continuous type there is constipation, loss of appetite, general indisposition, lassitude, a frequent aching in the right iliac fossa and tenderness on deep pressure.
- (8) No danger of perforation or any other complications.

Appendicitis

- (1) Attack well defined.
- (2) Pain colicky or sharp and moderate or severe in character at the beginning of the attack. It may continue or subside.
- (3) Pain at first generalized and later localizes itself to the right iliac fossa.
- (4) Nausea and very frequently vomiting.
- (5) Tenderness, hypersensitivity to touch, muscle spasm of varying degree over the right iliac fossa.
- (6) Fever and leucocytosis of varying degree.
- (7) Danger of perforation and peritonitis.

Etiology of Appendicitis and Appendicosis.—I observed that in a very large number of appendices either with inflammation or mucosal erosion type of appendicosis the initial lesion could be recognized to have appeared in the mucosa. Occasionally, particles of faecal material were present in the mucosal furrows or "bays" and in some instances, firmer and sharper particles had pierced and injured the mucosa. (Fig. 1.) These observations were made possible by the study of stained longitudinal sections of the entire organ. A section so cut offered a view of the lumen and the opposing walls of the whole organ which could not be achieved by the usually prepared cross-sections.

A röntgenological study of the appendices of normal persons was made. It was noticed that the appendix filled passively but expelled material by

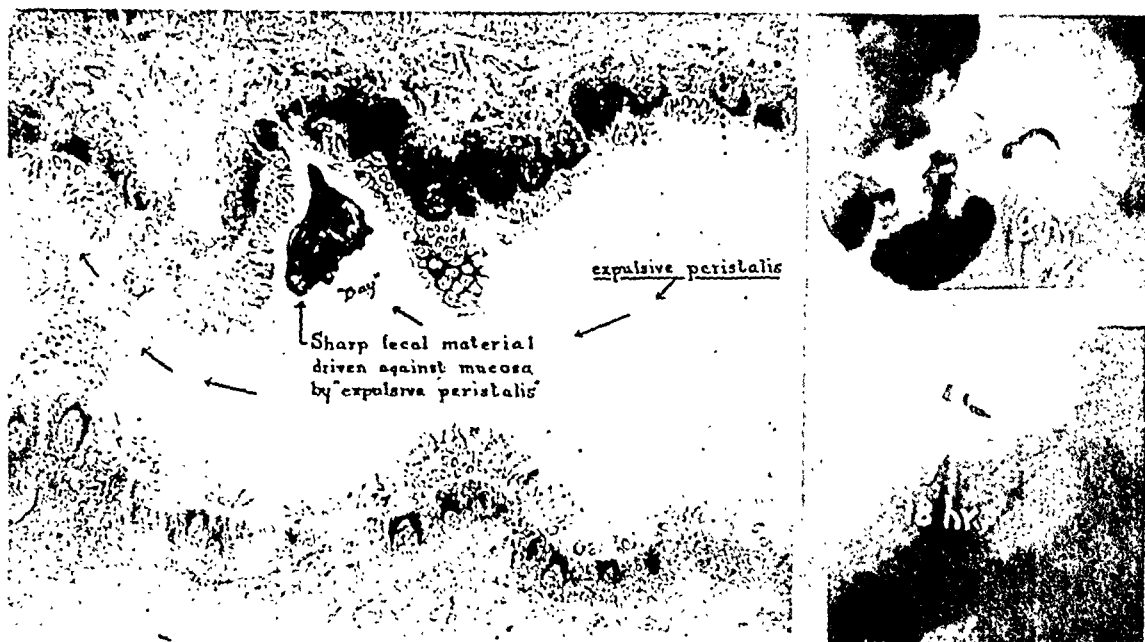


FIG. 1.

FIG. 2.

FIG. 1.—Longitudinal section of part of appendix shows a sharp faecal body with a mucosal injury opposite. The arrows indicate the direction of peristalsis.

FIG. 2.—The appendix is seen expelling material—expulsive peristalsis. The tip is still visualized; the rest of the tract is free of barium.

peristaltic contractions which began at the tip. (Fig. 2.) These peristaltic waves continued for hours until the entire organ was free of barium. Jordan¹⁴ had made similar observations. In view of these findings it was concluded that during the process of expulsive peristalsis sharp particles of faeces are driven into the mucosal bays and due to repeated impacts they pierce and lacerate the appendiceal mucosa. These findings and conclusions do not, however, explain the conditions which determine the causation of appendicitis and appendicosis.

To determine the relation of the bacteria in the appendiceal lumen to the production of lesions, a bacteriological study of normal appendices, those with appendicitis and with appendicosis, was made. Similar to the results obtained by most of the other investigators, no particular organism or group of organisms was found to be common to one or the other type of appendiceal

lesion, nor did these bacteria differ from those in the normal appendices. Smears of the appendiceal contents and of the mucosa from all parts of the appendix controlled the complete isolation of all the bacteria present in the organ.

Although numerous investigators determined the type and number of the appendiceal bacteria, no determinations of the pathogenicity of the isolated bacteria were done. If the bacteria have any etiological relationship to the mucosal injuries, injection of these bacteria into similar tissue may elicit their pathogenicity for this particular type of tissue. Consequently, a culture of each isolated microorganism was injected intracutaneously into dogs. It was found that all or some of the bacteria from appendices with appendicitis produced abscesses in the areas injected. (Fig. 3.) On the other hand, the bacteria obtained from the mucosal erosion type of appendicosis seldom

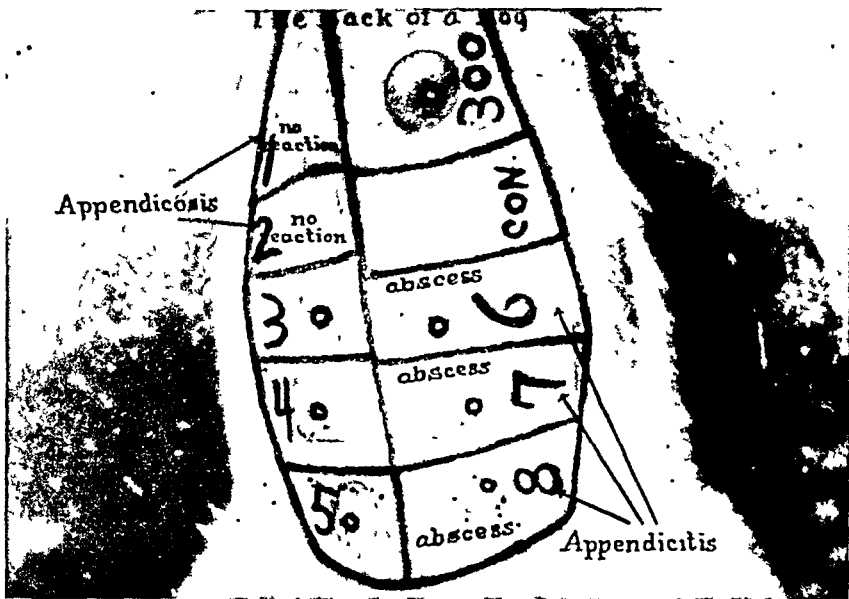


FIG. 3—Reactions from intracutaneous injections of appendiceal bacterial cultures.

showed a reaction or only a slight induration in the skin of the animal. It was deduced that though the bacteria may be similar in type their pathogenicity varies and determines the formation of an inflammatory or a degenerative lesion. In presence of pathogenic organisms the mucosal injury produced by sharp faecal particles driven by the expulsive peristalsis results in a mucosal ulcer which is followed by various degrees of inflammation (appendicitis). If the organisms are not pathogenic, no inflammation sets in and a mucosal erosion results. Since the type of the microorganism is the same in appendicitis as in appendicosis, it is assumed that the difference in the pathogenicity is due to factors resident in the lumen of the appendix. These factors remain subjects for further investigations which may eventually lead to artificial methods in rendering the appendiceal bacteria non-pathogenic.

The retrogressive type of appendicosis which I designated¹³ "pressure atrophy type" is produced by a different mechanism. The change in this type

ETIOLOGY OF APPENDICITIS

is that of compression of the wall. From the röntgenological observations it is concluded that this condition is due to stagnation in the colon. There is interference with emptying of the appendix and the continuous pressure increases the appendiceal contents, which distend the lumen and lead eventually to atrophy of the wall. The outstanding and frequent symptom in this type of appendicosis is constipation accompanied by lassitude and an indefinite complaint of indigestion.

Summary.—Retrogressive and degenerative lesions of the appendix (appendicosis) are differentiated clinically from the inflammatory lesions (appendicitis).

The mechanism of production of appendicitis and appendicosis is explained. Sharp particles of faecal material are propelled by the expulsive peristalsis of the appendix into mucosal bays and injure the mucosa. In presence of an environment within the appendix favorable for growth of bacteria appendicitis results; in absence of such an environment the bacteria are rendered non-pathogenic and appendicosis is the outcome.

BIBLIOGRAPHY

- ¹ Ricker: Quoted by Aschoff, L.: Ueber rudimentäre Appendicitis Gleichzeitig ein Beitrag zur Frage der funktionellen Bedingungen der Appendicitis. Beitr. z. path. Anat. u. z. allg. Path., vol. lxxvii, p. 141, 1927.
- ² Rosenow, E. C.: The Bacteriology of Appendicitis and Its Production by Intravenous Injection of Streptococci and Colon Bacilli. J. Inf. Dis., vol. xvi, p. 240, 1915.
- ³ Portis, B.: Clinical and Pathological Aspects of Appendicitis. Soc. Trans., Philadelphia Path. Soc., February, 1929.
- ⁴ Aschoff, L.: Ueber rudimentäre Appendicitis Gleichzeitig ein Beitrag zur Frage der funktionellen Bedingungen der Appendicitis. Beitr. z. path. Anat. u. z. allg. Path., vol. lxxvii, p. 141, 1927.
- ⁵ Heile: Zur Entstehung der Appendicitis. Deutsche Ztschr. f. Chir., vol. ccxxvi, p. 309, 1930.
- ⁶ Bowen, W. H.: Notes on the Etiology of Appendicitis. Guy's Hosp. Rep., vol. lxxix, pp. 61-69, 1929.
- ⁷ Gross: System of Medicine, p. 639, 1882.
- ⁸ Niedermeyer, A.: Getreide und Appendizitis. Deutsche Med. Wchnschr., vol. 1, p. 716, 1924.
- ⁹ Isabolinsky, M.: Zur Bakteriologie der Appendicitis. Centralbl. f. Bakteriöl., vol. lxxiii, p. 488, 1914.
- ¹⁰ Bagger, S. V., and Mikkelsen, O.: Bacteriology of Appendicitis. Hospitalstid., vol. lxxvii, p. 289, 1924.
- ¹¹ Warren, S.: The Etiology of Acute Appendicitis. Am. J. Path., vol. i, p. 241, 1925.
- ¹² Aschoff, L.: Über Chronische Appendicitis. Med. Klin., vol. xxiv, p. 1660, 1928.
- ¹³ Steinberg, B.: Degenerative Lesions of the Appendix (Appendicosis) Hitherto Undifferentiated from Appendicitis. Am. J. Clin. Path., vol. i, p. 339, 1931.
- ¹⁴ Jordan, A. C.: Chronic Intestinal Stasis. Oxford Medical Publication, pp. 100-102, London, 1923.

MYXOGLOBULOSIS (VON HANSEMAN) OF THE APPENDIX

BY VICTOR G. HENTZ, M.D.

OF NEW YORK, N.Y.

FROM THE SURGICAL DEPARTMENT OF THE MIDTOWN HOSPITAL

APPENDECTOMY has become a major part of everyday surgery. The majority of cases present such an ordinary pathological picture that the surgeon usually approaches the operation with no real apprehension as to clinical findings. However, though it is rarely encountered, we do find mucocele and pseudomyxoma of the appendix. Because of the comparative scarcity of literature on the subject, this paper is presented.

Obliteration of the appendicular lumen due to foreign body, *i.e.*, fecalith, with mucous degeneration of the distal portion, was first described by Rokitsansky in 1861. Virchow next mentions, in 1863, retention cysts of the appendix which resemble mucous glands. In 1901, Fränkel reported an autopsy finding where large gelatinous masses, originating from the appendix, were found in the cæcal fossa. As recently as 1909, Elbe reported that only 150 cases of this unusual disease were to be found in the literature and the statistics of Glawirovsky show that of all appendices operated and reported upon, only 0.6 per cent. show this anomaly. Even more unusual is the condition first described by Von Hanseman. He reported that upon examination of a cyst in the appendix, he found, situated near mucous masses, small kernels resembling sago seeds or fish roe. This he termed myxoglobulosis.

If, in the healing process of an appendicitis, stricture forms, sterile mucus retention might result distal to this obstruction. This is called mucocele. This stricture is usually caused by inflammation. However, various agents such as tuberculosis, dysentery, carcinoid tumors, as well as small echinococcus cysts near the cæcal end of the appendix can be considered factors in causing obliteration. Robbed of the possibility of draining into the cæcum, the mucus becomes thicker and gelatinous, the mucin changing into pseudo-mucin and colloid and forming a homogeneous mass. The mucous membrane of the appendix is either destroyed through pressure or forms small diverticula. Von Hanseman found these diverticula to be usually situated opposite the mesenterial attachment. In them or in the excretory canals of the mucous glands, broken-up cells will accumulate from which the central portions of the previously mentioned kernels are formed. Lymphocytes and stellate cells are found in them very rarely. The kernels present on cut surface an opaque centre and glassy outer cover. Their size varies from a few millimetres to one centimetre.

In his report, Michaëlsen⁶ presents his findings of a gelatinous mass with a network of connective tissue-forming strands and occasional epithelial cells of cylinder and columnar type. Based on findings of his own and of Nael-

sund, who produced this condition experimentally in animals, Michaelson contends that the appendicial epithelia may be implanted in the abdomen and may proliferate. This may be compared to the proliferation of normal epithelium in the traumatic epithelial cysts in the so-called atticus fistulæ or with the retention cysts in the outer chamber of the eye. Connection of the cyst with the free abdominal cavity through perforation will cause the formation of gelatinous deposits in distant parts and gives the picture of pseudomyxoma peritonei.

Two aspects of the disease present themselves in the clinical picture. The first is circumscript and is caused by the fact that the pseudomucinous fluid remains confined within the walls of the appendix, thereby forming a cyst. The second is diffuse and is caused by the fluid diffusing between the layers of the cæcum, thereby producing myxomatous degeneration. Owing to the thin wall of the cyst, traumatic or spontaneous rupture may occur. In the case of Frænkel, reported in 1910, disseminated pseudomucinous peritonitis was present as a consequence of a ruptured cystic appendix.

If spontaneous perforation takes place, the gelatinous fluid will seep through the small opening and by means of peristalsis of the intestines will be deposited even in distant parts of the abdomen. It is a moot question how the gelatinous material thus distributed proliferates. In Ewing's⁷ opinion, the pseudomucinous material passes into the lymph spaces of the peritoneum. To quote the opinions of Werth, Günzberger and Westphalen: "These spaces become distended and ruptured, the material infiltrates the meshes of the peritoneum, round-cell infiltration, growth of granulation tissue and proliferation of endothelium result and the peritoneum is everywhere thickened by a painless form of peritonitis." It seems most probable that the appendicial mucous cells carried away in the peritoneal cavity continue to function and to produce pseudomucinous fluid. Otherwise, how can the occasional presence of enormous amounts of gelatinous material be explained?

Ewing further quotes Wirth and Polano, who give another possibility, namely, that mucous fluid without tumor cells may migrate in the lymph channels along the portal system into the liver or into the appendix and there set up new growths. Although lymphatic connection between the right ovary and the appendix is not yet firmly established, still our finding of an enormous pseudomucinous cyst of the right ovary associated with the simultaneous finding of myxoglobulosis of the appendix as in our case reported below, further substantiates this belief.

Present-day knowledge is not sufficient to answer the question as to whether the pseudomucinous fluid in the abdominal cavity is inflammatory or neoplastic. That it may be inflammatory is borne out by the fact that a pseudomucinous condition has been reported in some cases to have spontaneously regressed while in others it took a neoplastic course.

Clinically, myxoglobulosis gives the picture of chronic appendicitis. The appendicular symptoms are due to pressure changes of the enclosed gela-

tinuous masses. The symptoms are analogous to those described by Ashoff in stone-free dyskinetic cholecystic attacks which are of a nervous reflex nature. *Per se* it has never been diagnosed. Usually it is an occasional finding or is diagnosed only at autopsy, as in the cases of Von Hanseman and Michaelson. The obstruction in the appendix is usually the result of an appendicitis or tumors, as in the cases of Spassokukoczky where a carcinoid, and that of Huter, where an adenocarcinoma was found. While pseudomyxoma peritonei is found mostly in women, myxoglobulosis shows prevalence in males. In Birkenfeld's¹ statistics of twenty-six cases, only five women were affected by the disease.

Therapy consists of the removal of the diseased appendix. In pseudomyxoma peritonei, as much as possible of the gelatinous material should be removed. If the disease is of ovarian origin, the affected ovary and con-

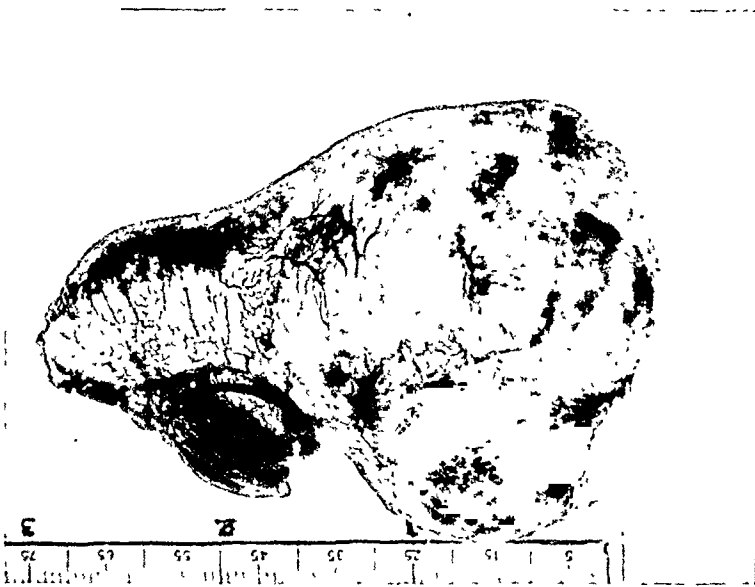


FIG. 1.—Shows the size of the appendiceal cyst. Mesenterial fat attached. No constricting band separates the more and less distended parts.

sidering the bilateral tendency of the disease, it might be advisable to remove the other ovary and the omentum. Bearing in mind that a malignant degeneration may take place, post-operative radiation is justified.

CASE HISTORY.—A woman, fifty-two years of age, by occupation a housekeeper, first seen August 21, 1931. For the last five months observed fullness in the abdomen with stubborn constipation. Lately abdomen has grown larger but has not caused her any other symptoms except discomfort and short breath on exertion. Menses were regular since eleven years of age, lasting four to five days, without pain or discomfort. Three births; no abortions. At forty-three had a severe hæmorrhage, following a menstrual period and lasting fourteen days. After curettage her periods became normal again and continued so for three months, when again metrorrhagia developed and continued for three months without cessation. Examination revealed the presence of fibroid tumors of the uterus with bilateral ovarian cyst. Complete hysterectomy and partial oöphorectomy were done ten years ago. She never had any attacks attributable to appendicitis. She has been well ever since until recent illness.

MYXOGLOBULOSIS OF APPENDIX

Examination revealed a large fluctuating mass, the upper end of which reached the xyphoid process. No free fluid in the abdomen. No tenderness on pressure present. Appendix region not tender. No resistance was palpable inasmuch as the cystic tumor filled the abdominal cavity.

At operation September 8, 1931, a large ovarian cyst was found emerging from the stump of the right ovary. The left ovary had been entirely removed at the previous operation. Aspiration of the ovarian cyst was done, whereby six quarts of pseudomucinous, sanguinolent fluid were withdrawn. The cyst and ovarian rest were removed.

As a routine procedure the appendix was looked for and found to be distended to form a smaller cyst measuring three by two inches. The cyst wall was transparent with a few lime deposits inclosing an apparently clear fluid. No constricting band was seen and the pear-shaped cyst seems to continue without break to the also distended proximal portion of the appendix. (FIG. 1.) The appendix was removed.

Histological examination showed the fluid withdrawn from the ovarian cyst to be pseudomucin. The wall did not show anything unusual.

Section of the proximal end of the appendix showed hypertrophy of the muscle coats with polymorphonuclear infiltration of the mucosa and submucosa. Occasional eosinophile and stellate cells present. Normal gland structure partly destroyed. The cystic part contains thickened mucus and an abundance of small globules, their sizes ranging from millet to sago seeds. A few loose fibrous bands traverse the cystic cavity. Cut surface of the kernels is grayish and around the opaque centre a slimy outer cover is seen. The centre of these globules consists of colloid and broken-up cells, which could not be identified.

Patient made an uneventful recovery. When seen twice since then the scar remains firm. She is apparently in good health, without any sign of recurrence.

BIBLIOGRAPHY

- ¹ Birkenfeld, W.: Myxoglobulosis, Von Hanseman, and Strangulation Ileus. *Zentralbl. f. Chir.*, vol. lviii, pp. 210-213, January 24, 1931.
- ² Irsigler, F. I.: Mucocoele Followed by Pseudomyxoma. *Zentralbl. f. Chir.*, vol. lviii, p. 408, February 14, 1931.
- ³ Muir, J. B. G.: Mucocoele of Appendix. *Lancet*, vol. i, p. 131, January, 1931.
- ⁴ Sussi, L.: Mucocoele of Appendix. Pseudomyxoma of Peritoneum. *Policlinico*, vol. xxxvii, p. 568, November, 1930.
- ⁵ Gucci, G.: Peritoneal Pseudomyxoma of Appendicular Origin. *Arch. ital. di Chir.*, vol. xxviii, pp. 524-530, 1931.
- ⁶ Michaelson, E.: Peritoneal Pseudomyxoma of Appendicular Origin. *Acta chir. Scand.*, vol. lxviii, pp. 37-54, 1931.
- ⁷ Ewing: *Neoplastic Diseases*. Third Edition, p. 636, 1928.

BRIEF COMMUNICATIONS

INFLAMMATORY CYST OF THE BREAST

CHRONIC cystic mastitis, blue-domed cyst and serous-retention cysts are considered fairly common conditions, but it is quite rare to see the development of a solitary cyst following a chronic abscess. However, chronic abscesses are occasionally found, especially those being due to specific diseases, particularly tuberculosis. Reclus^{1,2} recorded a case in which a small nodule appeared with a mastitis after delivery and which suppurated six years later.

Abscesses of the breast are occasionally seen as a complication of pregnancy. Spontaneous rupture of the abscess is unusual, due to the deep situation of the abscess and the pain experienced by the patient, which nearly always forces them to consult a physician. Chronic pyogenic abscesses are unusual, thereby probably accounting for the absence of a reported case similar to this one.

CASE I.—A colored woman, aged thirty-two years, was admitted to the Emory University Division of the Grady Hospital August 31, 1931. The chief complaint was an enlargement of the right breast. This came on during a pregnancy six years before. The mass was described as being small at the onset and accompanied by considerable pain. The swelling increased for several days and then finally ruptured spontaneously. A thick yellow pus discharged for four or five days and then the opening closed. The baby was delivered a few months later. However, she was unable to nurse it from the right breast due to pain. At no time did the breast return to its normal size.

One year later the woman became pregnant and the breast again began to swell and was very tender. A spontaneous rupture with discharge of a large amount of pus occurred a short time afterwards at the site of the original opening. Closure of the opening took place in a few days. There was a period of quiescence of four years until a few weeks before admission, when the swelling increased but was not accompanied by pain as at former times. The discharge from the opening then was a thick, brownish, watery fluid.

Physical examination was non-essential except for the right breast. There was a globular swelling of the entire breast, which measured 6.5 by 6 centimetres. A small stellate, depressed scar was located three centimetres to the right of the nipple. The mass seemed to occupy the entire breast, which was soft and semi-fluctuant. There was no enlargement of the axillary nodes.

Laboratory examinations, including blood Wassermann, were negative.

A probable diagnosis of cyst of the breast was made and operation performed August 15, 1931. An elliptical-shaped incision was made around the entire breast and it was removed down to the pectoral muscles. (Fig. 1.) On opening the breast there was revealed a thick-walled sac which occupied the entire breast, being surrounded by only a small amount of subcuticular tissue and fat. The cyst measured six by five centimetres. The sac contained a thin, odorless, straw-colored fluid. Two definite layers of the wall of the cyst were made out. The outer was a light-colored, thick, fibrous one and measured two millimetres in thickness. The inner one was irregular, dark and brown, with a thickness of three millimetres. At the upper and outer portion of the cyst was a small tract which lead to the scar on the skin surface. (Fig. 2.)

INFLAMMATORY CYST OF BREAST

Microscopical examination (Dr. E. L. Bishop) showed a fibrous capsule outside of which was an area of acellular connective tissue with several groups of acini and some

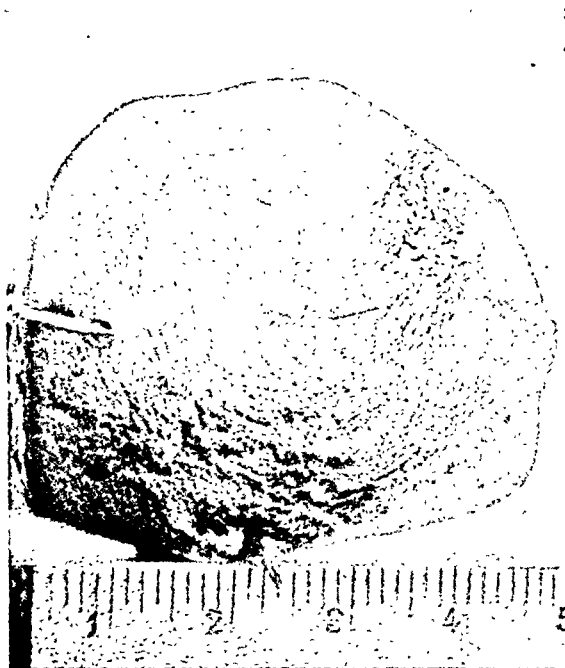


FIG. 1.



FIG. 2.

FIG. 1.—Outer surface of breast showing opening on the skin.

FIG. 2.—The opened cyst showing two layers of cyst wall with the cavity and tract leading to the surface.

normal-appearing fatty tissue with scattered lymphocytes. (Fig. 3.) There was a clear-cut line of demarcation at the cyst wall, which was densely fibrous, with scattered small



FIG. 3.



FIG. 4.

FIG. 3.—Lower-power microscopical picture showing the two layers of wall.

FIG. 4.—High-power magnifications showing large, premature fat-cells and the spaces left by cholesterol crystals.

injected vessels. There were no cellular areas in the capsule. Lymphocytes and vessels were present in increasing numbers as the central portion was approached. At the

line of the cyst cavity was a thick area of vascular granulation tissue and a large number of lymphocytes, plasm-cells and a few leucocytes. In several of the larger vessels there were numerous leucocytes. Few areas of fat-cells, some proliferating, and many degenerating, were seen. (Fig. 4.) A great many elongated crystals were represented by open spaces with a tendency for foreign-body giant cells to form about these crystals. There were scattered areas of necrosis and small areas of hæmorrhage with some blood pigment in a few areas. No glandular structures of anything of neoplastic character was seen.

Diagnosis.—Chronic abscess with suggestive traumatic fat necrosis.

This case exhibits considerable resemblance to traumatic fat necrosis, but at no period was there a history of injury. However, according to Gattleman and Zemansky,³ it is questionable the part trauma really plays, as in their twenty reported cases it was an infrequent finding.

If this case had been seen at an earlier date before the serous effusion accumulated, the picture might have been similar to a fat necrosis, which clinically must always be differentiated from carcinoma. The probable sequence of events in this case was abscess formation on two occasions with spontaneous drainage and rapid closure of the opening, leaving a pyogenic wall which did not heal from within outward and which assumed secretory characteristics.

JOHN D. MARTIN, M.D.

Atlanta, Ga.

From the Dept. of Surgery of Emory University.

BIBLIOGRAPHY

¹ Quoted by Fitzwilliam, p. 89 (On Breast), 1924.

² *Idem*, p. 79.

³ Gattleman, J., and Zemansky, A. P.: Traumatic Fat Necrosis of the Breast. *ANNALS OF SURGERY*, vol. lxxxv, pp. 438-449, March, 1927.

MENINGEAL HÆMORRHAGE WITHOUT INTRACRANIAL SYMPTOMS

It is usually on the symptoms and signs that a diagnosis of meningeal hæmorrhage is made. A case of unconsciousness with the primary concussion followed at a later period with consciousness which again gives way to a second unconscious period carries great weight in diagnosing meningeal hæmorrhage. There may be any form of scalp, skull or brain injury with the rupture of the meningeal artery. Hæmorrhage requires trephining and ligation of the bleeding point. If depression occurs it requires trephining and elevation. If a simple fracture of the vault occurs without hæmorrhage, depression or brain symptoms, or if a slight depression occurs without brain symptoms or if symptoms were present and are abating, it can be treated expectantly.

If the depression is marked a trephine should be done even if no symptoms are present, except in young children with pliable skulls. DaCosta advocates trephining all cases of fractures of the base; first it is exploratory

and again it is a preventive trephining against later complications, as epilepsy, insanity, change of character and septic inflammations, *etc.*

CASE REPORT.—M. J. N., a four-year-old child, was brought to the Guam Naval Hospital with hematoma of scalp and history of injury. Three days before admission when he was crawling out from under a house being constructed a piece of lumber four by four inches square and about three feet long fell from the roof and with one end struck him on the right side of the head. He was knocked unconscious immediately; a swelling developed on the right front temporal and parietal areas. He was a well-nourished child; the right side of his head and eye were swollen. No open wounds were seen.

There was a large hematoma on the right frontal temporal and parietal regions. The right eye was nearly swollen shut. There was no subconjunctival hæmorrhage although he had a black eye. There were no ocular muscle palsies, the pupils reacted normally and were equal and regular, and the fundi showed no abnormalities. There was no facial palsy or weakness, the tongue was not paralyzed, there was no nasal, pharyngeal or other bleeding. No spinal fluid to indicate fracture into the nasal cavities. The ears showed no hæmorrhage or spinal fluid. Battles' sign not present. There were no external open wounds anywhere on head. No fracture or depression could be felt. The hematoma had its hard "rim" around it. The neck was normal. The chest and abdomen were normal.

The reflexes of the extremities were normal. Sensation was normal. No difficulties with urination or defecation.

Spinal fluid.—No blood, normal cell count and globulin but the pressure was increased a little on admission.

X-ray showed the skull fractured throughout nearly three-fourths of the circumference of the vault and extending into the base!

Comment.—We have here a case of skull injury caused by a direct force of the bursting type. A hematoma formed but no spinal fluid was under the scalp. He was not seen at the hospital for over seventy-two hours after his accident and his history suggested merely a concussion at the time of the accident which lasted about two hours. After the reaction from this he had no further unconsciousness at any time. On admission he had no palsy, no headache, no vomiting, no choked disc, no face flushing, no altered pupils, no abnormalities of blood-pressure, pulse or circulation, no eye-muscle palsies, no subconjunctival, nose or ear hæmorrhage, no stupor or excitement, no altered function of urination or defecation and only a slight rise of temperature, yet he had a fracture of his skull which extended nearly three-quarters of the way around the skull and extended into the base. He was symptomless in spite of an extensive injury. No external wound was present except the hematoma which showed that a contusion had been suffered. The only suggestion of intracranial injury was the increased pressure of the spinal fluid and this was only suggestive as the child was wiggling and jumping while the tap was being made. His pulse was not irregular at any time after admission. The question of treatment was to be decided upon.

As a large hematoma is a possible source of embolism and as the fracture seemed to extend into the base it was decided to open the hematoma, explore the skull and possibly trephine. The X-ray suggested an area of depression which gave one more stimulus to operate. Operation was done

under ether and with rigid asepsis as we had an old bloodclot to deal with. Upon opening the scalp the extensive fracture was found and in the temporal region an area about the size of a quarter was found markedly depressed. A trephine opening was then made just above this area and it was elevated. The fracture line was rather wide and considerably separated. After the trephine opening had been made a clot was found on the dura about the size of a half-dollar, which, when removed, exposed two small tears in the middle meningeal artery. At a short distance from this area another clot was found which seemed to be from bleeding from the fracture line itself. All clots were removed, bleeding stopped by ligatures and bone wax and the wound closed. There was no subdural bleeding. He was kept in bed one month, he had a good and speedy convalescence, and left the hospital in good condition. He was given urotropin before and after operation.

This case may have got well if we had done nothing but possibilities of embolism from the hematoma, and of late effects from the injury and the clots such as epilepsy, insanity, infections or change of character, *etc.*, must not be lost sight of. He had no symptoms and yet he had a very extensive fracture with extradural hæmorrhage. It is possible that the skull fracture, being so extensive, allowed the top to give and thereby no intracranial pressure was caused. The relief of the pressure was accomplished by a fracture—separation substitute for trephining; that is, prior to operation.

Now, six months after the injury, there are no after effects such as palsies, hernia cerebri, insanity, epilepsy, change of character or inflammatory phenomena.

WILLARD S. SARGENT, M.D.,
Lieut. Med. Corps, U. S. Navy.

A DOUBLE-BREASTED MATTRESS SUTURE

IN NO field of surgery is there more of a demand for an exact technical procedure than in the repair of large ventral hernias. These hernias are either primary, such as an umbilical hernia, or secondary to some abdominal operation in which suppuration of the abdominal wall, including the fascia, occurred. These hernias vary in size; some of their hernial openings are large enough to admit a hand. The details of the removal of the sac and the separation of adhesions are familiar. The closure of the hernial opening as described in most text-books is accomplished by overlapping the upper flap over the lower flap in a transverse direction, with interrupted chromic sutures.

The suture that the writer is about to describe has all the advantages of the mattress suture, but, in addition, it not only brings together the free

DOUBLE-BREASTED SUTURE

edge of the lower flap to the under surface of the upper flap, but it also brings together the free edge of the upper flap to the anterior surface of the lower flap, thereby obtaining a double line of approximation with a smooth inner peritoneal and outer fascial surface.

Fig. 1 enables one to visualize the various steps of this new suture. A No. 2 or No. 3 double chromic suture on a good, strong, curved needle is used. The suture enters at 1 in the upper flap about an inch away from its free edge; passes through the free edge of the lower flap, down to its peritoneal surface. It then passes about a quarter of an inch across to the left through the free edge of the lower flap, back again through the upper flap, again an inch away from the free edge. The suture then passes down to

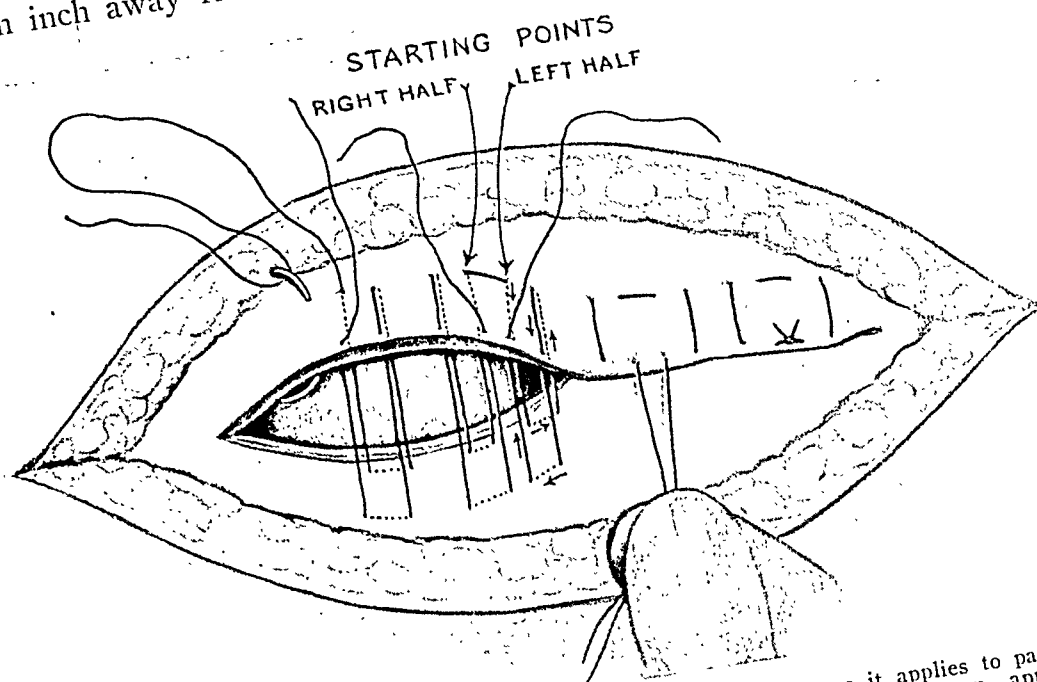


FIG. 1.—A double-breasted mattress suture. From left to right as it applies to patient. The first suture is completed. The ends of the second suture are pulled upon, approximating the flaps preparatory to tying it. The third suture indicates its complete course taken through the flaps. Note the pulley effect at five points of the suture. The arrows indicate the course of the left half; the same course is taken by the right half but in the opposite direction. To the extreme right only half of the suture is completed. The suture may be continued to complete its other half (as indicated by the needle) or the ends of the one-half may be tied and accomplish the same result but only for half the distance. This is especially applicable when only a remaining small gap in the fascia is to be approximated. This illustration applies to a hernia closed in a transverse direction. To visualize a hernia closed in a longitudinal direction, all one has to do is to hold the illustration in a vertical position.

the free edge of the upper flap and through the lower flap to its peritoneal surface, which is about an inch away from its free edge. The needle then passes from the peritoneal surface back to the right a quarter of an inch and passes through from the peritoneum through the lower flap and through the free edge of the upper flap reaching the outer surface of the fascia. This needle is then unthreaded, the other end of the same suture, which is left long, is threaded on the needle and passed through the upper flap and the free edge of the lower flap about a quarter of an inch to the right, and from then on the same steps are repeated until the needle reaches to the

free edge of the upper flap a quarter of an inch away from the other end of the suture. (Fig. 2.)

When these two ends are pulled upon the upper flap overlaps and becomes approximated to the lower flap in the same manner as do the flaps on a double-breasted suit. The peritoneal surface feels smooth, with no wrinkling; the outer aspect appears evenly approximated, with no dead space. Three or four such sutures accomplish a perfect closure of even a large ventral hernia. One of these sutures is sufficient to close the average epigastric or umbilical hernia. Should the incision of the hernia be vertical

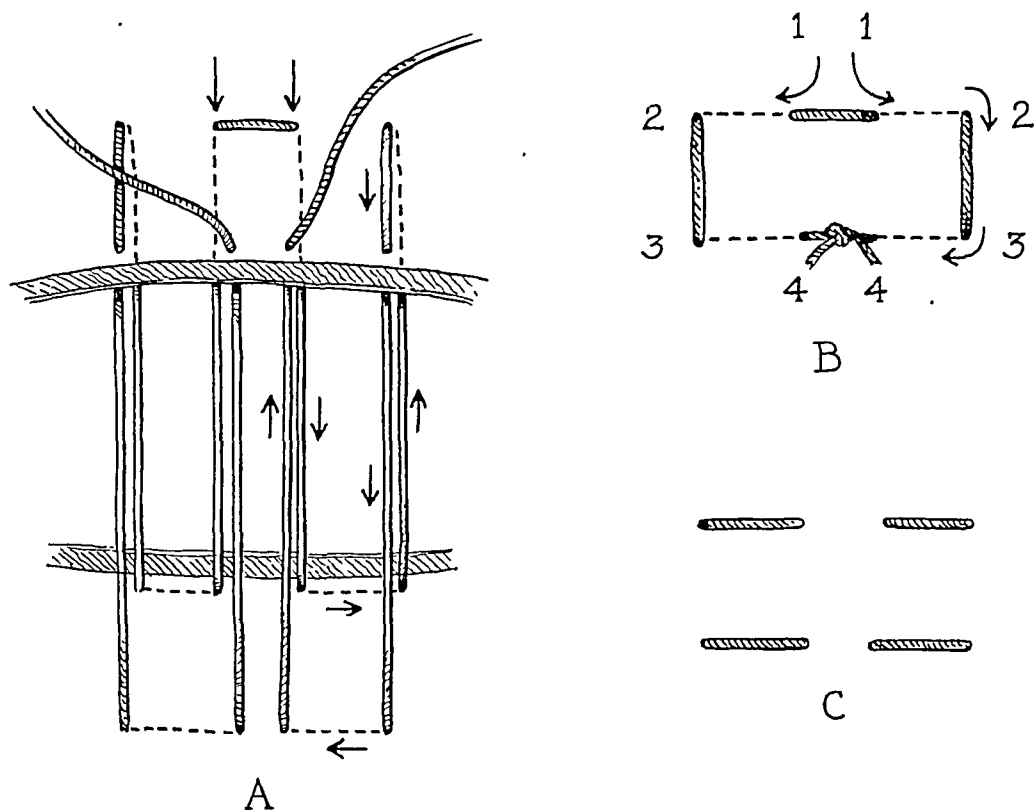


FIG. 2.—Diagrammatic.—A.—Presents the suture passed, but not tied. The direction of the two halves is indicated by the two arrows on top. Follow the course of the left half as indicated by the arrows. The right half takes the same course but in the opposite direction. B.—Shows the suture tied as viewed from its outer aspect. 1 and 1 indicate the start of the respective halves of the suture. 1-4 indicate the points where the suture passes through both flaps. The dark lines indicate the loops of the suture on the outer aponeurotic surface. The dotted lines indicate the loops on the inner peritoneal surface. C.—Indicates a view of the suture as would be seen from within the abdominal cavity.

the same procedure can be used by overlapping the flaps in a longitudinal direction.

An attempt to close the hernial opening with this suture impresses one with the ease with which these flaps automatically approximate. This is accounted for by the pulley-like effect produced when the free ends of the suture are pulled upon before they are tied.

JACOB SARNOFF, M.D.
Brooklyn, N. Y.

WOUND HEALING AND SKIN GRAFTING

THIOCRESOL IN WOUND HEALING AND IN SKIN GRAFTING

REIMANN,¹ in 1930, published an original article on the clinical use of thiocresol for the stimulation of wound healing, reporting excellent results. With the exception of a second paper by Reimann,² in 1931, dealing with the further use of thiocresol to excite cell proliferation and thickening of the skin, there have been no other reports commenting on the clinical value of this drug.

In his first publication, Reimann based his theory on the results of Hammett,³ who found that the essential difference between the nucleus of a cell in mitosis and the nucleus of a cell in the resting state was the "rearrangement of the sulphur in the molecules, so that this element appears in a chemical group, Sulphydryl;⁴ *i.e.*, SH-". Applying this discovery clinically, he deduced that sulphur in the proper form would stimulate wound healing. This he and Hammett⁴ demonstrated on rats. Unfortunately, the SH- group also stimulated bacterial growth. Therefore, Reimann attached cresol to the SH- radicle, forming a labile compound, thiocresol. Applied to wounds, the cresol splits off, inhibiting bacterial growth without retarding the cellular progress. Bettmann⁵ described a similar problem which he met by the incorporation of oxyquinoline sulphate and chlorbutanol (antiseptics) with scarlet R ointment (stimulating to the epithelium).

We have used thiocresol since the publication of Reimann's original article. We have applied it impartially on denuded areas resulting from burns, on sloughs (traumatic or surgical), decubitus ulcers, and on all other areas where denudation has been present. We are convinced that Reimann's treatment has benefited denuded areas which had been resistant to all other methods of treatment, that a tough and durable epithelium is produced, that convalescence is shortened, and that the method has the added advantage of simplicity and economy. As examples of our results the following cases are reported:

CASE I.—A male, aged fifty-five years, was admitted June 27, 1931, with second- and third-degree burns of both feet and ankles. While asleep in a park, a boy had poured gasoline on his shoes and set them on fire. His admission temperature was 102° F., pulse was 128, and respiration 30. Tannic-acid treatment was started immediately, spraying 10 per cent. tannic acid every fifteen minutes. A black crust formed, but the patient's temperature remained high. Therefore, on July 2 the crusts were removed and extensive suppuration was found underneath. Saline and magnesium sulphate compresses were applied continuously until July 8, when treatment with thiocresol was started. At the end of forty-eight hours a definite increase of epithelium was noted, especially on the left foot. July 15 the left foot was entirely healed; and on the 21st the right foot and ankle were also entirely healed. The reason ascribed for the slower healing of the right foot was that there had been a greater loss of the deep tissues.

CASE II.—A male, aged sixty-three years, was admitted June 29, 1931, with the diagnosis of second-degree burns of right foot and ankle, also received from gasoline burns, received under the same circumstances as Case I. On admission, the temperature, pulse, and respiration were normal. Tannic-acid treatments were started, and again the result was suppuration underneath the black, dry crusts. Continuous saline and boric compresses were applied from July 1 to the 9th, when thiocresol was started. Healing was complete on July 18. He was discharged August 5, 1931.

The method used in the application of thiocresol moistenings was that described by Reimann. A 1-10,000 solution of thiocresol is poured on pieces of gauze which are applied directly to the wound. Over the moist gauze

should be wrapped a sheet of rubber or oiled paper to prevent too rapid evaporation. The frequency of moistening the gauze depends on the size of the wound, the place of the wound, the amount of healing present, and the amount of evaporation that has taken place. As a rule, it is necessary to apply fresh solution every four hours. As pointed out by Reimann, fresh solutions should be used. There are two ways of preparing a fresh solution of the required strength; either the method originally described which is as follows: 1-100th gram of the crystals dissolved in 5 cubic centimetres of 95 per cent. alcohol, diluted in 100 cubic centimetres of distilled water, giving a 1-10,000 solution; or a stock solution may be made up of the crystals dissolved in alcohol and diluted with water as the occasion arises.

We have not noted the too extensive granulations supposedly formed through the prolonged use of thiocresol. It has been used continuously for as long as three weeks and longer without this reaction taking place. Therefore, the admonition of using the solution for forty-eight hours and the discontinuing it for twenty-four hours seems unnecessary. We have observed a continuous and rapid proliferation of epithelium from the wound margin and from dormant central islands with a continuous improvement in the whole wound appearance. The epithelium grows whether suppuration is present or not. Neither have we noticed the blister formation described by Reimann in his second paper.

Since the beneficial action of thiocresol is due to the stimulation of mitosis, the early successes prompted a trial of the treatment as a post-operative dressing on skin grafts. Results on two cases follow:

CASE III (Fig. 1).—A man, aged twenty-three years, was admitted July 8, 1931, suffering from second- and third-degree burns of both legs. On admission the temperature, pulse, and respiration were normal. Tannic-acid treatment was started. But, on July 13, the temperature went up to 102° , pulse to 100, while the respiration remained normal. On July 16, the tannic-acid crusts were removed, and from then on the temperature which had remained almost constantly at 102° slowly decreased so that by the 22nd it reached normal. But the condition of both of his legs was not at all what could be desired. Moist dressings of saline and boric solutions were applied continuously. In a week the temperature again began to rise, so that on August 4 it reached 103° , and from then on it showed a septic curve, reaching at times 104° in the afternoon and dropping to normal in the morning. The condition of his legs became steadily worse. All the surface of both legs from below the ankles to above the knees were completely covered with soggy granulations overlaid with a thick layer of purulent exudate. In places loss of the deeper tissues took place, so that craters one inch in depth could be found. The pain was intense so that the dressings became more and more difficult. Contractures were beginning, the knees flexed and feet drawn down by the Achilles' tendons. The patient finally became unmanageable. In such a condition he was referred to our service September 4, 1931. The next day Thiersch grafts from the thigh were placed on both legs. All the granulating surfaces could not be covered, nor was such an attempt made. To the grafted areas were applied continuous moist dressings of 1-10,000 thiocresol. The dressings were not removed until ten days post-operatively. Underneath the purulent discharge were found islands of grafts which covered most of the previously denuded areas. The thiocresol dressings were continued with the hope that no more grafts would be necessary. The dressings were not changed

WOUND HEALING AND SKIN GRAFTING

for periods of eight to ten days. At the end of twenty-eight days the result was perfect, the denuded areas being covered with healthy epithelium except at the places where there had been a greater loss of the deeper tissue. Over these areas were applied more Thiersch grafts. By October 24 all the previously raw areas were covered with epithelium (Fig. 1) and the patient was up on crutches. Two weeks later he was walking unaided, and in another two weeks he was driving a car.

CASE IV.—A male, aged twenty-six years, was admitted November 18, 1931, with a terminal denudation of an amputation stump of the upper third of the left humerus. The area measured four by three inches. Thiersch grafts taken from the thigh were



FIG. 1.—Lateral view of Case III, showing the final result of the extensive burns following the use of Thiersch grafts and post-operative dressings with thiocresol.

placed on the wound. The post-operative treatment consisted of continuous moistenings with thiocresol. Two weeks later he was discharged to the Out-patient Department with almost complete epithelization. Two days later all dressings were removed, the denuded areas being completely covered with durable epithelium.

Comment.—Thiocresol has proven to be very stimulating to wound healing and of real clinical merit. In none of the cases have we found the granulations growing as fast as the epithelium, thus simplifying the technic. It has not been necessary to do anything but apply the solution to the gauze bandages wrapped about the lesions and leave them undisturbed. We have

observed that after the removal of the wet dressings healing seems to progress almost as rapidly as under the thiocresol compresses, indicating a cumulative action on the epithelial cells. This might prove of value in the use of thiocresol moistenings on ambulatory cases.

I. R. BIRNBAUM, M.D.,

Akron, Ohio.

Orthopaedic Service of the City Hospital.

BIBLIOGRAPHY

- ¹Reimann, S. P.: Use and Reasons for the Use of Thiocresol to Stimulate Wound Healing. Jour. Am. Med. Assn., vol. xciv, pp. 1369-1371, May 3, 1930.
- ²Reimann, S. P.: Thiocresol in Wound Healing. ANNALS OF SURGERY, vol. xciii pp. 624-627, February, 1931.
- ³Hammett, F. S.: The Chemical Stimulus Essential for Growth and Increase in Cell Number. Protoplasma vol. vii, pp. 297-322, August, 1929.
- ⁴Hammett, F. S., and Reimann, S. P.: Cell Proliferation Response to Sulphydryl in Mammals. Jour. Exper. Med., vol. 1, pp. 445-448, October, 1929.
- ⁵Bettmann, A. G.: A Simpler Technic for Promoting Epithelization and Protecting Skin Grafts. Jour. Am. Med. Assn., vol. xcvi, pp. 1879-1881, December 19, 1931.

NOTE ON THE ETIOLOGY OF ACUTE PANCREATITIS

WE REPORT the end-result of a gastroenterostomy for pyloric stenosis due to carcinoma that not only blocked the pylorus completely, but also, after a time, the gastroenterostomy opening, resulting in an apparently complete exclusion of the duodenum, the biliary system and the pancreas, which led before death to huge dilatation of the duodenum, forcing of the sphincter of Oddi, a wide-open pancreatic duct and a common duct big enough to admit the average thumb with dilatation of all the branches of the hepatic ducts far up into the liver. The case is especially interesting because of its bearing on the etiology of acute pancreatitis. A brief résumé of the case is as follows:

A man, aged sixty-seven years, was admitted to hospital with a history strongly suggestive of carcinoma of the stomach. Röntgenograms showed a lesion of very long standing with a hugely dilated stomach. When his abdomen was opened there was found only a hard, fibrotic, somewhat puckered plaque about the size of a fifty-cent piece on the anterior wall of the stomach just at the pylorus, apparently an old ulcer, with almost complete obstruction of the pylorus. The gall-bladder contained a few faceted stones but was very little thickened. No gross evidence of carcinoma was recognized and a posterior gastroenterostomy some six inches from the pylorus was done and a tube put in the gall-bladder after removing the stones. The common duct was not dilated and no stones were felt in it. He left the hospital in six weeks, rapidly gaining weight and feeling well. He returned four months later with pain in his epigastrium, increasing weakness and loss of weight. There was now a palpable mass in his pyloric region and an infiltration of his abdominal wall—obviously carcinomatous. An X-ray showed the stomach contracted to one-fourth its former dimensions with a complete block at the pylorus and the gastroenterostomy in a contracted state very close to the pylorus and functioning hardly at all. He died six weeks later. At autopsy (Fig. 1) his stomach was small with a mass of the consistency of cartilage infiltrating the pyloric

region and extending along the greater curvature a short distance beyond the gastro-enterostomy, which was now only about two and one-half inches from the pylorus. The gall-bladder was atrophic and there was an abscess containing about four ounces of odorless pus in the right lobe of the liver beneath the gall-bladder. The duodenum was three times its normal size and very tense with fluid. The common duct was an inch across, and tense. The papilla of Vater was wide open and the duct contained no stones. The hepatic ducts were greatly dilated up to their small subdivisions in the liver. The pancreas had been to some degree invaded by the growth which was adherent to its head. The pancreatic duct opened near the orifice of the papilla and did not seem much dilated. The remainder of the pancreas showed no gross lesion and microscopical sections showed no evidence of inflammation.

Acute pancreatitis has always been something of a puzzle. In most instances the classical finding of a gall-stone impacted in the lower ampulla,

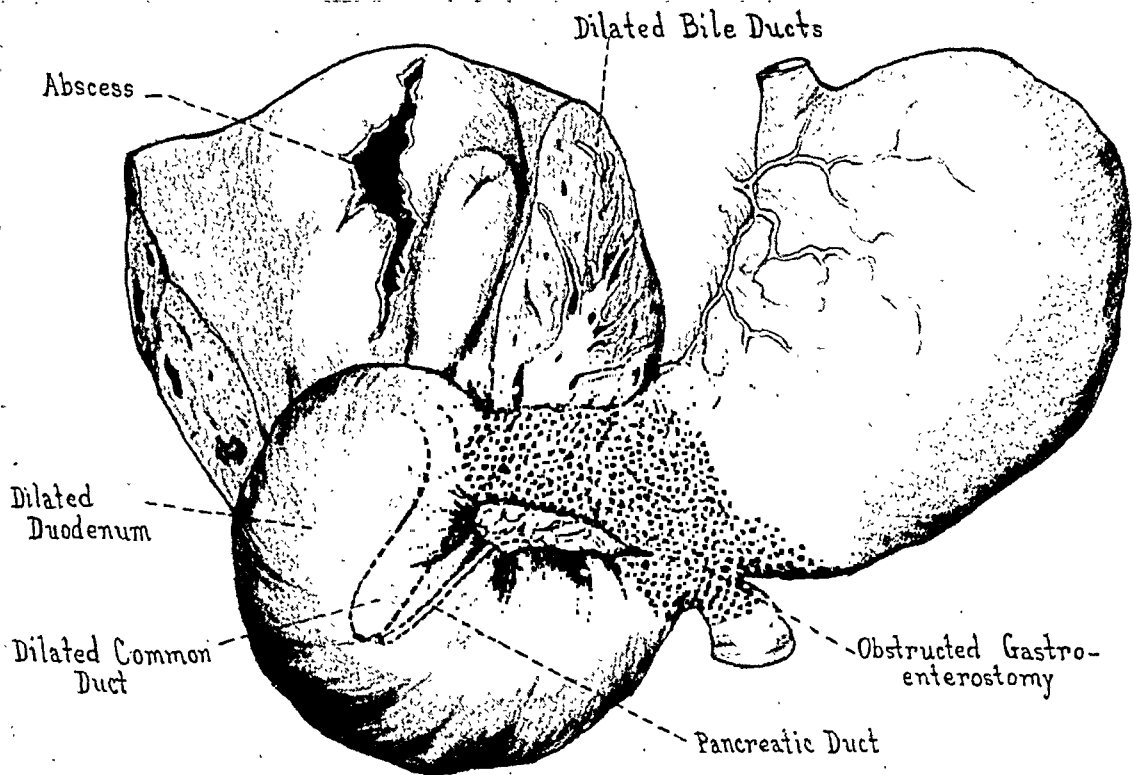


FIG. 1.—Diagrammatic illustration of condition found at autopsy.

as described by Opie, is lacking, but when this has been occasionally found it has been thought by many to be the soundest explanation of its occurrence. Macallum* says regarding it: "The cause was quite obscure until Opie discovered a case in which a small gall-stone had become impacted in the orifice of the ampulla of Vater in such a way that neither bile nor pancreatic juice could escape although bile could run back from the common bile-duct into the pancreatic duct. Opie readily showed that injection of bile into the pancreatic duct would produce acute hæmorrhagic pancreatitis in animals and Flexner showed that gastric juice and many other irritating substances would do so too. He found that fresh bile was most effective, that mucus rendered its action far milder and produced rather chronic effects." The

* Textbook of Pathology, p. 398.

other notions about the cause of acute pancreatitis are not pertinent to this discussion. Here we had developed a hydrostatic pressure from accumulation of biliary pancreatic and duodenal secretions sufficient to dilate the duodenum to three times its normal size, force the sphincter of Oddi, dilate greatly the whole biliary tree and leave the pancreatic duct opening into the duodenal cloaca, so to speak, with free communication back and forth of the fluid containing bile, duodenal secretion and pancreatic juice. No doubt this mixture was less irritating than pure bile. Surely this isolation of the duodenum came about gradually and could not have long been complete but it seems remarkable that acute pancreatitis did not develop.

RICHARD JOSEPH WHITE, M.D.,
MAY OWEN, M.D.,
Fort Worth, Texas.

BOBBIN ATTACHMENT TO SCISSORS OR NEEDLE HOLDER FOR LIGATING AND SEWING

FIG. 1.—Shows scissors with bobbin attached to carry ligature material. The long arm of A fits into the tube attached to the scissors, each being flattened on one side. Bobbin B slips on the split short arm of A which provides the proper tension for the former.

Fig. 2.—Needle-holder showing bobbin attachment holding a full tube of catgut. The needle has an eye in the point end with a large guide ring on the other end.

A is a guide tube attached to a two-arm piece. To mount, slip end of tube into ring on needle holder, then pull the lower arm back into short flattened tube on rear of shank. Bobbin B slips on split arm of A. C is a large common needle four inches long used as a shuttle.

To use the scissors with bobbin, the suture is brought through a small hole under the mounting tube. The knot is best tied with the left hand for economy of gut. If much tying is to be done, as in goitre operations, two tubes of ligatures may be wound on the spool or a second bobbin used.

It gives the assistant more time to handle hæmostats and the ligatures and scissors are always together. I have reduced my ligating time 50 per cent. I find that non-boilable catgut, the kinks of which can be eliminated by stretching, is best adapted to this method of tying and suturing.

There are two principles involved in the sewing apparatus. First, broader surfaces are available for healing; second, the strain of the wound is placed more upon the sutures than upon the tissues.

At first glance sewing by this method seems complex, but in reality it is very simple. You have a tube of catgut that will close the average incision. For each layer but one knot is tied, while it is not necessary to attach hæmostats to the peritoneum or fascia for as the suture is introduced the cut edges are drawn into a vertical position, making introduction of the next stitch easy, while the last stitch holds the tissues so securely that they do not slip apart. (See Fig. 3.)

The threaded needle is introduced through the cut edges of the distal end of the peritoneum or fascia. The free end of the catgut is pulled through. It should be about two inches longer than the incision, *i.e.*, it should reach to the opposite end with enough more to allow for tying. A common heavy rug needle three or four inches long should be tied on the free end as a shuttle. The needle is withdrawn and reintroduced about one-quarter inch from the first. By slightly withdrawing the needle the suture will loop so that the shuttle needle in the left hand of the operator can be pushed through the loop

BOBBIN-EQUIPPED NEEDLE-HOLDER

FIG. 1.

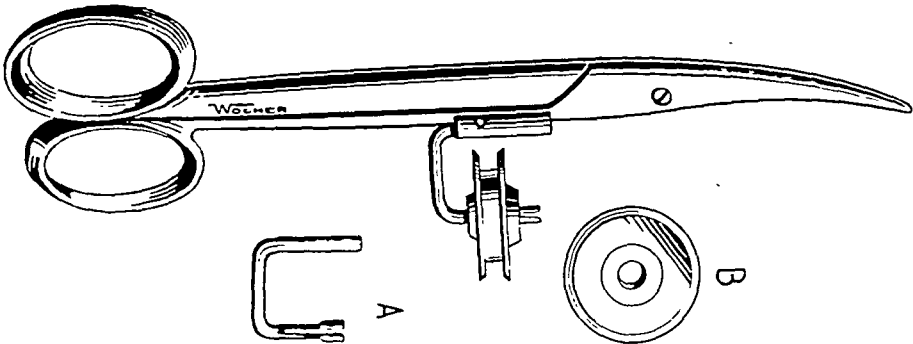


FIG. 2.

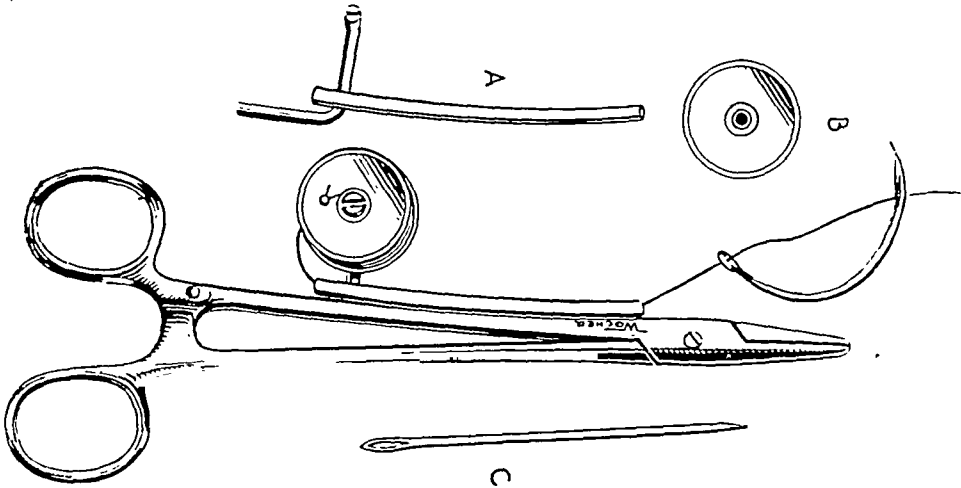
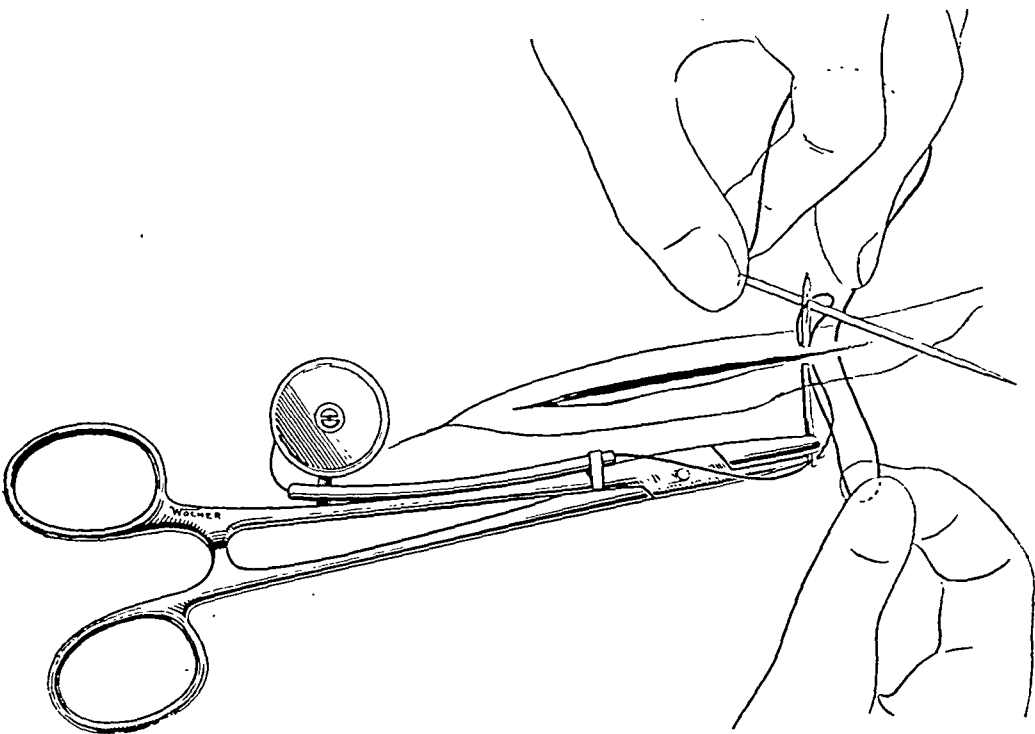


FIG. 3.



on the side distal to the needle. The assistant, I find, should hold his side of the suture lightly between the index finger and thumb of his right hand during the introduction of the needle, and when the needle is withdrawn he takes the suture between the same fingers of the left hand, pulling it parallel with the incision toward the unclosed end. At the same time, the operator pulls the shuttle end of the catgut in the same direction. When the layer is closed, the suture is cut and tied and the next layer closed likewise. If you believe in closing the muscle layer, you can use interrupted sutures with no trouble. *Always pass the shuttle or free end of the gut through the loop distal to the eye of the needle*, otherwise your needle will be caught.

Advantages.—(1) The peritoneum is closed securely with the cut edges extra-peritoneally.

(2) The fascial layers have broader surfaces for healing and the cut edges stand up ideally for the introduction of figure-of-eight stay sutures.

(3) It is a fine method for closing the first layer in gall-bladder operations for it prevents the troublesome splitting of the fibres of the transversalis muscle and fascia.

(4) It is a quick and simple method for introducing mattress sutures in operations for umbilical hernia; also for single or double sutures in inguinal hernia.

(5) It is well adapted for skin suture with silk, dermal or catgut. The suture should be placed near the edge for good coaptation; tension of sutures should be avoided in the skin for the suture is hæmostatic. It is quickly and painlessly removed by taking out the straight locking suture and the knot, the other half ravel out instantly.

(6) In pelvic work there is no loose catgut to entangle the hæmostats.

(7) As a hæmostatic stitch, I have tried it on the intestines of animals and find it makes a beautiful and strong anastomosis.

(8) This bobbin can be attached to any kind of scissors or needle-holder. The apparatus can be removed instantly if the operator desires to use the older methods.

KELLEY HALE, M.D.,
Wilmington, Ohio.

LIPIODOL IN DIAGNOSIS OF RETAINED COMMON BILE-DUCT STONE

IN A previous communication to this journal* a study of lipiodol injections of post-operative biliary fistulæ was reported. In that series we were unable to report visualization of a common-duct stone as such, although, in one instance, the presence of a common-duct stone had been correctly postulated by demonstrating an obstruction at the papilla of Vater. In the present communication Case I is reported, firstly, to supplement the previous series by presenting a plate actually showing a retained common-duct stone, and secondly, to illustrate that variations in quantity of lipiodol injected may affect visualization. Case II is reported to illustrate the type of indirect evidence leading one to suspect the presence of a retained common-duct stone following cholecystostomy.†

Both cases illustrate the feasibility and advisability of performing a cholecystostomy as a first-stage operation in severely ill patients with common-

* ANNALS OF SURGERY, vol. xci, pp. 233-241, February, 1930.

† Cases from the surgical service of Doctor Neuhof, the Mount Sinai Hospital, N. Y. C.

LIPIODOL IN BILIARY DIAGNOSIS

duct obstruction. Prerequisites for this type of operation are of course a patent cystic duct and the presence of bile in the gall-bladder. The nature of the common-duct obstruction can then be fairly accurately determined at a subsequent stage by a lipiodol injection and the appropriate second-stage procedure performed.

CASE I.—E. F., aged sixty-one, was admitted to the surgical service of Doctor Neuhoof in May, 1930. For thirty-six hours he had been suffering from violent epigastric



FIG. 1.—Plate taken after the first injection showing a definitely outlined defect in the lipiodol shadow at the lower portion of the common duct, caused by a retained stone.

pain and repeated vomiting. He was suffering intense pain, was markedly prostrated, and had marked right upper quadrant rigidity and tenderness. Under observation for twenty-four hours the patient experienced a chill, prostration became extreme, and a slight icteric tinge appeared in the scleræ. Operation revealed an enlarged, tense, acutely inflamed gall-bladder which, on aspiration, yielded pus and bile. Because of the poor general condition of the patient it was thought inadvisable to do an extensive exploratory

BRIEF COMMUNICATIONS

procedure and the operation was accordingly limited to a simple cholecystostomy with evacuation of pus and sandy material.

Three weeks later lipiodol was injected through the cholecystostomy sinus under fluoroscopical control. A radiotransparent area which was gradually encircled by the injected lipiodol could be seen. At the same time lipiodol could be seen entering the duodenum in little trickles, rather than with the rush usually observed.

In September, 1930, patient returned for re-operation and a soft stone was removed in segments from the lower portion of the common duct. The stone could not be felt by external palpation of the common duct through the foramen of Winslow.

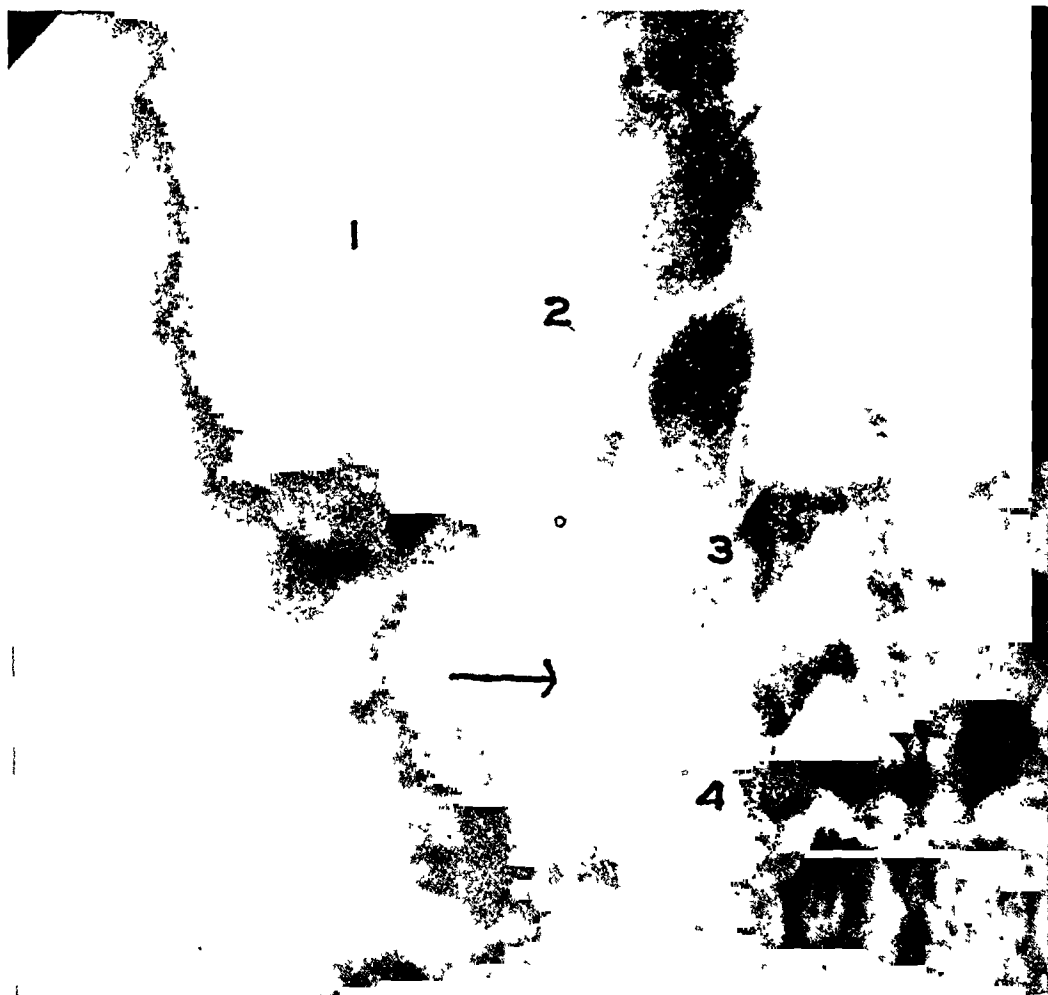


FIG 2.—Plate taken fifteen minutes later, after the injection of ten cubic centimetres more of lipiodol. The defect caused by the stone is obscured by the shadow of the increased quantity of lipiodol. The retention of the lipiodol in the common duct and its slow emptying are indicative of obstruction. The arrow points to the common duct stone. 1—Gall-bladder. 2—Cystic duct. 3—Common duct 4—Lipiodol trickling into the duodenum.

CASE II.—E. M., aged sixty-three, was admitted to the Mount Sinai Hospital in January, 1931. One year ago she had been operated on for a toxic thyroid adenoma. She had been known to have high blood-pressure, as high as 230, systolic, for a number of years. She also had symptoms and electrocardiographical findings of coronary artery disease. During the past year she had experienced a number of severe attacks of biliary colic with a rise in temperature to 104° , chills, and jaundice. Following one of these attacks she was admitted to the Mount Sinai Hospital with a temperature of 104° and tenderness and rigidity in the right lower quadrant. Stool contained bile and the icteric

LIPIODOL IN BILIARY DIAGNOSIS

index was only slightly raised. Her symptoms did not abate. Cholecystostomy was performed under local anaesthesia. The gall-bladder contained bile which was clear at the fundal portion and purulent near the neck. Because of the poor condition of the patient the operation was limited to removal of the gall-bladder stones and the performance of a cholecystostomy.

Six weeks later lipiodol was injected through a very narrow biliary fistula. Under

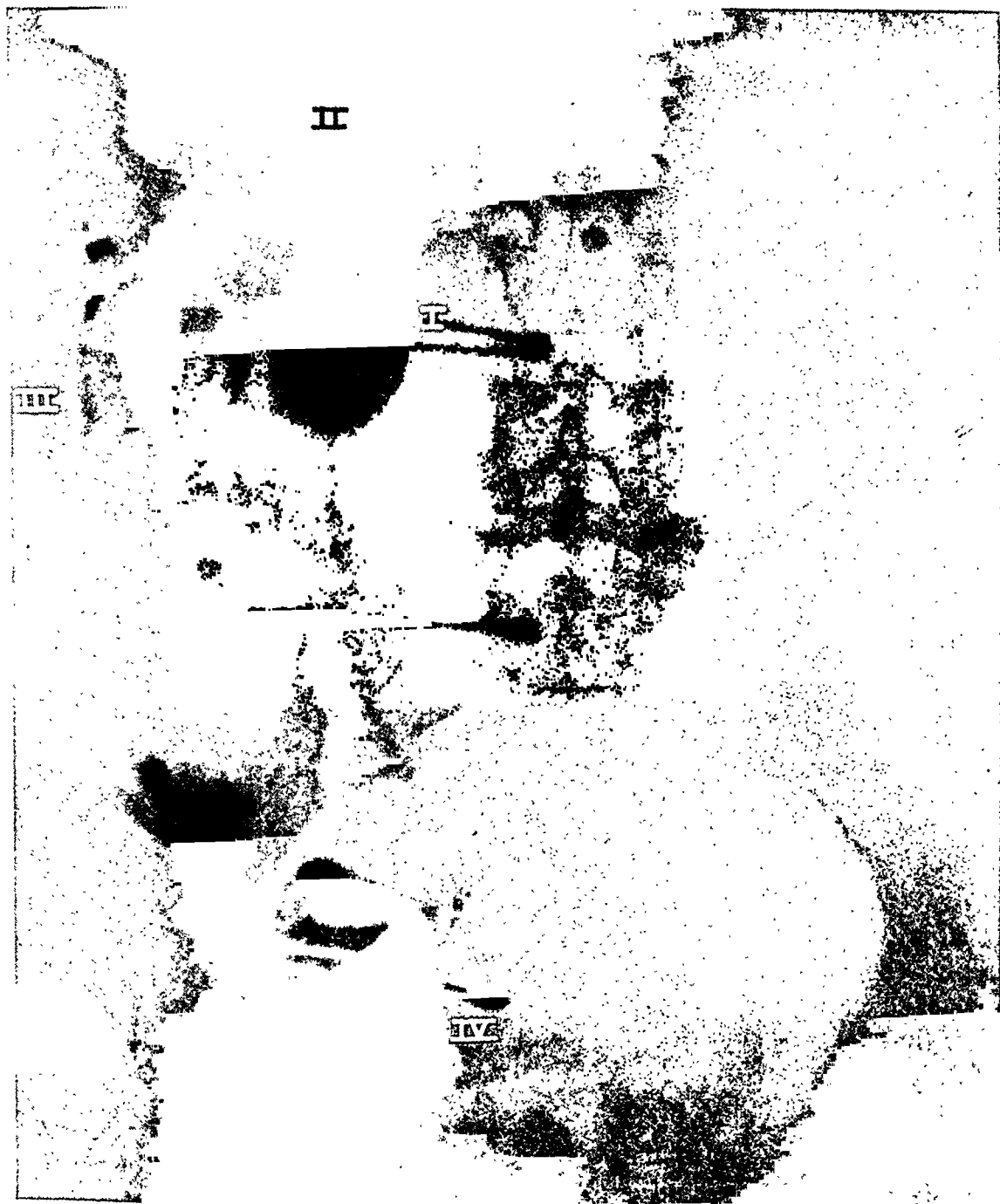


FIG. 3.—Case II.—Plate taken eighteen hours after lipiodol injection into the gall-bladder. The ascent of lipiodol into the intrahepatic radicles and its presence in the intestine indicates the presence of an incomplete obstruction in the common duct. The failure to visualize the common duct at the time of exposure indicates that the obstruction is relieved intermittently. 1—Gall-bladder. 2—Cystic duct. 3—Intra-hepatic biliary radicles. 4—Lipiodol in ileum.

fluoroscopical control 25 cubic centimetres of iodized oil were injected. The gall-bladder and cystic duct became gradually distended and peristaltic action could be observed. However, no oil was seen to enter the common duct, even after half an hour. A plate taken eighteen hours later, however, revealed the presence of lipiodol in some of the

intrahepatic biliary radicles of the right lobe. Lipiodol was also seen in the intestine. Forty-eight-hour plate showed the same condition. Seventy-two-hour plates showed the gall-bladder empty and the lipiodol had by this time disappeared from the biliary radicles. At no time was the common duct seen. From previous experience it was felt that the ascent of lipiodol into the intrahepatic radicles was indicative of an obstruction below the junction of the cystic and common ducts. The presence of lipiodol in the intestine indicated that the obstruction was incomplete. The failure to visualize the common duct indicated that the obstruction was intermittent in character. The most likely cause of such an intermittent obstruction was taken to be a ball-valve calculus. Operation revealed a very freely movable stone the size of an olive pit in the common duct.

LEON GINZBURG, M.D.,
New York City.

A CORK ADJUVANT TO THE MURPHY BUTTON

THE Murphy button for intestinal union as developed by Dr. John B. Murphy, in 1892, received general acclaim, but, lately, the strong interest and frequent use of the Murphy buttons has waned considerably. This is probably due more to our improved sewing materials, careful asepsis, and better methods of intestinal anastomosis by suture than to any inherent faults of the button itself.

However, there are special situations and locations for intestinal union where the button continues to serve best and has advantages over any type of suture anastomosis when estimated on a basis of speed, safety, and simplicity.

Regularly, the writers had preferred and employed it after difficult subtotal gastrectomies. Here we favor and perform a gastroenterostomy of the anterior type. To this long-loop type of anastomosis is added the necessary and important jejuno-jejunostomy between the limbs of the attached jejunum. This lateral anastomosis is rapidly and reliably accomplished with a Murphy button. After the completion of the posterior portion of the gastrojejunostomy, and before the anterior part of the stoma is closed, the separate hemispheres of the Murphy button are placed into the open limbs of the hooked-up jejunum. They are allowed to rest about four to five inches below the stoma. Each bowl of the button is so held that the cylinder thereof is firmly pressed against the anti-mesenteric border of the bowel. (Fig. 1.) This tensed diaphragm of gut is then incised crucially with a narrow scalpel to permit the cylinder to extrude through a small opening. An ordinary bottle cork previously fitted and of proper size is then quickly inserted into the hollow stem or cylinder (Fig. 2) to prevent intestinal leakage and to fix the button *in situ*, so that it cannot slip upward or downward, inward or outward.

Although only one select opportunity is here described in detail, any anastomotic demand that is best accomplished with the round Murphy button, *e.g.*, cholecyst-gastrostomy and ileo-colostomy, may be made more facile in its technical performance by utilizing the cork procedure.

THE MURPHY BUTTON CORK

Fig. 1.—a.—The cylinder of the Murphy button is forced against the anti-mesenteric border of the jejunum. A small crucial incision is made into the tense diaphragm of gut. b.—The stem of the hemisphere is extruded and the fitted cork is inserted therein.

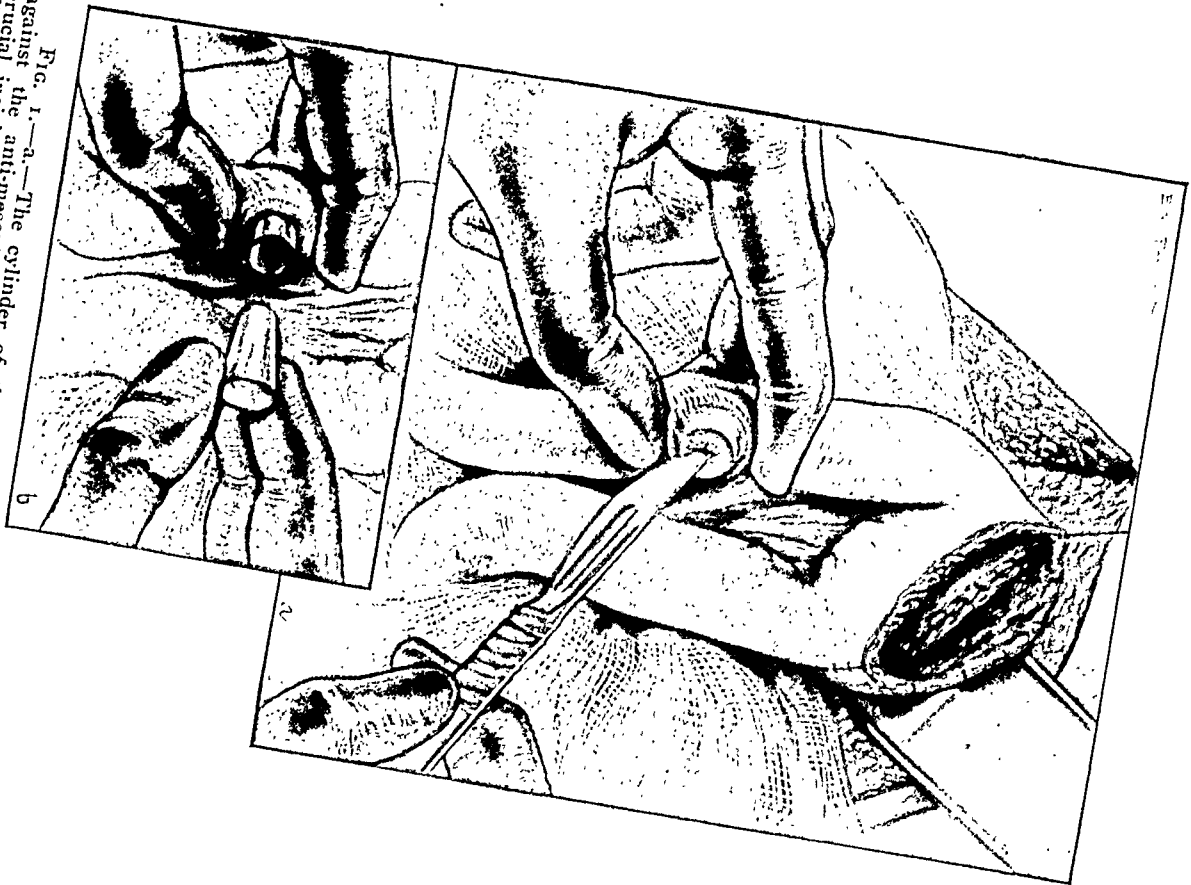
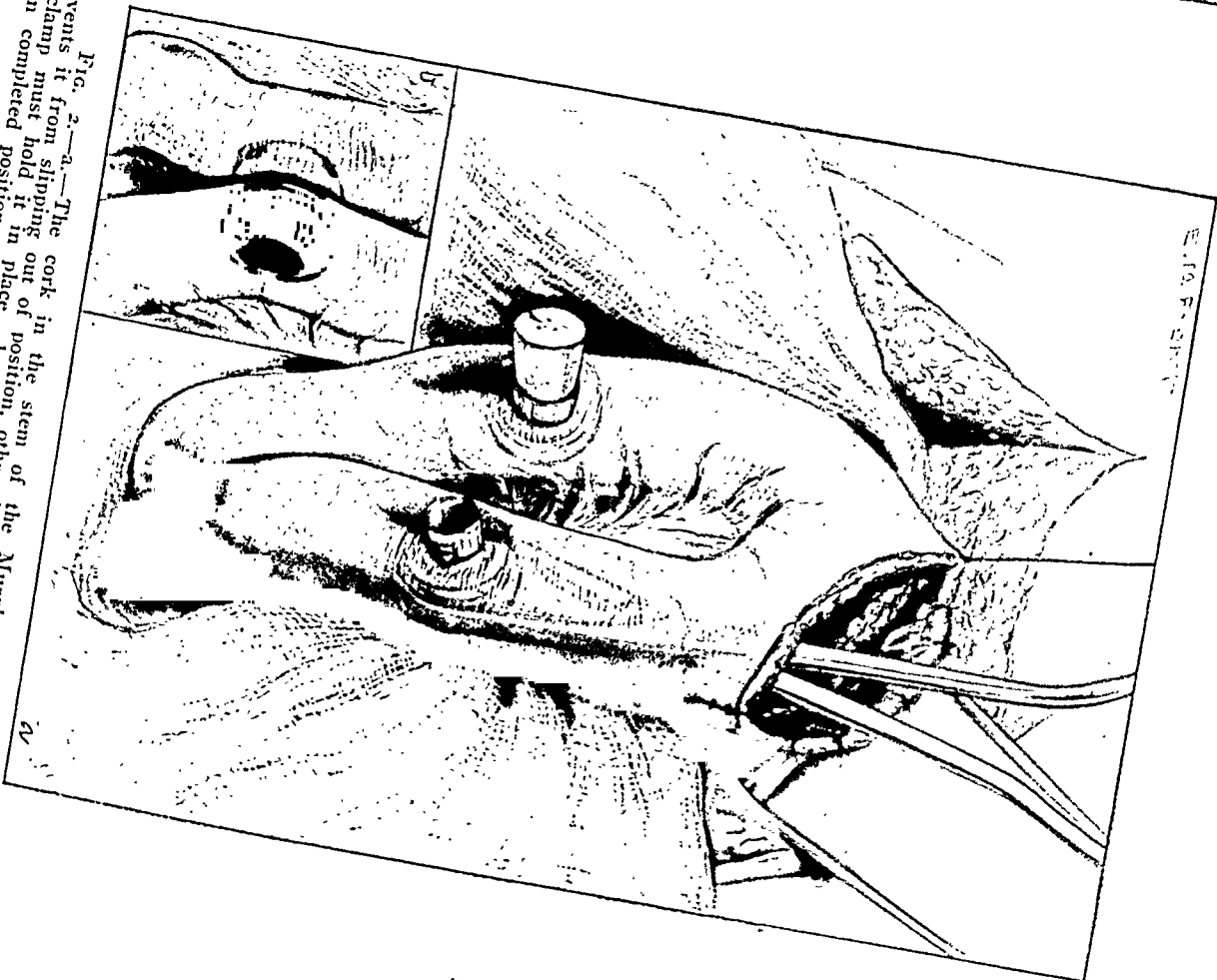


Fig. 2.—a.—The cork in the stem of the Murphy button prevents it from slipping out of position, otherwise the fingers or a long clamp must hold it in place. b.—The halves of the Murphy button in completed position.



BRIEF COMMUNICATIONS

The cork serves as a useful handle for the button, since it is easier to control than most special holding or ordinary clamps that are employed to steady or maintain the device while it is adjusted into its desired position.

WILLIAM L. WOLFSON, M.D.,
and MORRIS J. CLURMAN, M. D.,
Brooklyn, N. Y.

EDITORIAL ADDRESS

The office of the Editor of the *Annals of Surgery* is located at 131 St. James Place, Brooklyn, New York. All contributions for publication, Books for Review, and Exchanges should be sent to this address.

Remittances for Subscriptions and Advertising and all business communications should be addressed to the

ANNALS OF SURGERY
227-231 South Sixth Street
Philadelphia, Penna.

ANNALS *of* SURGERY

Vol. XCVI

OCTOBER, 1932

No. 4

TRANSACTIONS OF THE AMERICAN SURGICAL ASSOCIATION

MEETING HELD IN NEW HAVEN, CONN., MAY 16, 17 AND 18, 1932

ADDRESS OF THE PRESIDENT SURGERY OF THE SYMPATHETIC NERVOUS SYSTEM

BY CHARLES H. MAYO, M.D.

OF ROCHESTER, MINNESOTA

IN RECENT years there has been, on the part of certain investigators, an awakening of interest in the sympathetic nervous system, especially in its relation to diseases and functional disability of the tubular viscera, the glands, and the circulation.

Just two hundred years ago the term "sympathetic" was applied by Winslow to the system of ganglionated nerves. At that time, it was considered that these nerves did not supply skeletal or striated muscles other than the heart, but that they did supply the intestines and glands. In the study of some apparently new problems we often make progress by reading the work of the great men of the past, and I quote a few lines from John Hunter, the great anatomist, which were written in 1776, when we won what we thought was freedom, but Congress was unknown then:

"If it is asked why the involuntary parts have nerves at all, the answer may be given that it is not for their common actions, but to keep up the connexion between the whole, for without them an animal would become two distinct machines, and one might be acting very contradictorily to the other; but by the intercourse between will and voluntary parts, between the voluntary and involuntary, and also between these last and the mind, an universal and uniform agreement or regulation is kept up, which communication produces one kind of sympathy."

In 1800, Bichat introduced the term "vegetative" nervous system. In 1851, Claude Bernard, in his study of the physiology of the nerves to the extremities, which naturally included the gray rami of the sympathetic system, showed that section of the nerves led to dilatation of the vessels, and that stimulation of the peripheral ends of the nerves led to their constriction. We know now that vascular tonus is controlled by the gray rami communicantes which connect the sympathetic system to the somatic nerves. Gaskell, in

1886, described the regions of origin of nerves of sympathetic function as cranial, thoracic, lumbar, and sacral. The cranial outflow (principally in the vagus nerves), and the sacral outflow, or pelvic nerves, are described by most authors as parasympathetic nerves; they control normal peristalsis and occasionally reverse peristalsis. The thoracolumbar, or sympathetic, outflow delays or brakes progress by prolonged contraction. In 1898, Langley suggested the term autonomic system, to include both sympathetic and parasympathetic outflows. The cervical sympathetic nerves very largely exert their control in the thorax. The thoracic sympathetic nerves exert their influence in the abdomen, and by connection with the aortic plexus even in the pelvis. The sympathetic nerves for the pelvis branch out from the lumbar ganglia, and supply the pelvic portion of the colon, the bladder, and certain of the genital organs.

I may remind you here that the vegetative nervous system is largely the primitive nervous system, which regulates and controls the fundamental structures of the earliest forms of animal life and has been left in charge throughout all evolutionary progress. Disturbance of function of the sympathetic nervous system undoubtedly is often due to mistakes made by the cerebrum in matters of food and drink and bodily care, in addition to those disturbances caused by acute and recurring infections. Fortunate, indeed, is he who learns what foods or fluids cause unpleasant reactions of the skin, such as eczema, urticaria, and angioneurotic oedema, or which cause upsets of the stomach and intestines, or disturbances of the heart and blood-vessels. If we learn it at all, most of us learn of our special internal allergy too late to obtain much relief from circulatory troubles, or from the secondary diseases that result from spasm of smooth muscle within the body. A simple one is diverticula of tubular structures.

The sympathetic nervous system has control of approximately 75 per cent. of the energy expended by the body. We are now in a position to appreciate the benefit of having our bodies managed by the sympathetic nervous system, and we are beginning to appreciate the difficulties of readjustment of function, after pathological derangement of sympathetic nerves, or of hormones the "fluid nerves," elaborated by glands. We find that the latter often have a major relationship to disease, and are subject to derangement through such mental influences as worry, overwork, lack of rest and sleep, overeating, starvation and partaking of food and drink which are toxic or especially allergic to the individual.

THE SURGERY OF THE SYMPATHETIC NERVOUS SYSTEM

The sympathetic nervous system always has fascinated me. My attention was called to it again particularly in 1924, by the visit to this country of N. D. Royle and the late John Hunter, of Sydney, Australia; they presented most interesting considerations concerning the newer findings related to anatomical and physiological functions. The contributions of these men, added to what was already known of the sympathetic nervous system, opened

many avenues of investigation. I had learned of the researches of Royle and Hunter through the reports of W. J. Mayo, who, with Franklin Martin, visited Australia and New Zealand in the spring of 1924; in his comments on his visits to various medical clinics he expressed special interest in the work of Royle and Hunter.

Hunter and Royle thought that muscular tonus was a function of the sympathetic system. To support their views they made many experiments on animals, and even on birds; they found that when an animal was decerebrated, the resulting rigidity was less in a limb which had been previously sympathectomized. Royle applied this observation to cases of rigidity following war wounds of the central nervous system, treating them by ramisectomy of the brachial or lumbar rami communicantes, and he reported encouraging results. Unfortunately, this early promise has not been confirmed by the majority of workers in this field; Orbelli has expressed the view that any effects seen after sympathectomy may be ascribed to metabolic changes, mediated by the sympathetic system, in blood supply of muscle. But whatever the ultimate judgment on Hunter and Royle's operation for spasticity, the stimulating influence of their work entitles them to great respect.

Early Sympathetic Operations.—Jaboulay, in 1898, expressed the belief that pain in the lower part of the urinary tract passed to the spinal cord over the sacral rami communicantes, and he relieved some patients by ramisection made with difficulty and uncertainty by the posterior route, after resection of the coccyx. Jaboulay and Jonnesco, in 1906, popularized surgery of the cervical sympathetic ganglia for relief of exophthalmic goitre, especially for reduction of exophthalmos, and for the relief of epilepsy and angina pectoris. In this period, I removed the superior and middle cervical ganglia from several patients with hyperplastic thyroid glands and extreme exophthalmos. The operation reduced the size of the pupils of the eyes, and caused drooping of the upper eyelids, so that more of the cornea was covered and the retinal vessels were dilated, a picture known as Horner's syndrome; however, it did not seem to cause as much general benefit as did operations on the thyroid gland.

More than twenty years ago I started operating on the cervical sympathetic ganglia of patients with epilepsy, to increase the blood supply to the head. Following the method of Jaboulay and Jonnesco, I operated on a number of patients in two asylums for the insane, where patients with epilepsy are so commonly found. In some cases following operation the interval between attacks was prolonged, and in a number of cases the attacks were lighter, but I did not believe the results justified my applying the treatment to patients with epilepsy seen in general practice. We now know that the operative procedures did not extend low enough to increase the circulation to the head.

At about the same period, to relieve angina pectoris in two patients, I removed the superior and middle cervical ganglia, and also branches extending

to the lower cervical ganglion. In the second case, in addition to sympathectomy, I removed a cyst which I found in the angle of division of the right common carotid artery, and which I believed to be a cystic carotid body. In the first case, there resulted relief, graded at 50 per cent., from the severe anginal pains, and in the second there has been complete relief now for more than twenty years. At this time there is some enlargement of the aortic arch, but the patient is in his seventy-third year.

Recent Advances in the Surgery of the Sympathetic System.—Although many investigators were working on problems related to the surgery of the sympathetic nervous system, it was not until 1924 that the new work in this field was properly appreciated by the medical profession as a whole. In that year, led by Rowntree, Brown, and Hench in clinical medicine, by Adson, Craig and Learmonth in surgery, and by Mann in experimental investigation, the clinic made rapid strides in practical application of surgery to sympathetic nerves.

In vascular diseases, the work of Claude Bernard, came to fruition in the control of diseases which cause vascular contraction and decreased flow of blood; this group includes Raynaud's disease, selected cases of thromboangiitis obliterans or Buerger's disease, and selected cases of scleroderma. The measurement of vasodilatation which follows injection of foreign proteins, for example, typhoid vaccine, has provided a means of accurately estimating the possibilities of vascular distention. Brown and Sheard have designed a thermocouple which makes it possible to measure the changes in the temperature of the skin which follow such an injection. Adson and Brown have shown that the most favorable cases for operation are those in which the rise in temperature in the skin of the extremities is three to five times the rise in general temperature of the body. It is marvellous to see the relief which follows ganglionectomy and ramisectomy in Raynaud's disease; in Buerger's disease the results in selected cases are similar, but in some cases, although the extremities are warm and free from pain, and are restored to usefulness, there are still patchy changes in color due to permanent changes in the walls of some of the vessels.

Because of its associated interest, I wish to state the essential facts concerning a music teacher (a nun), aged thirty-three years. Starting with a normal systolic blood-pressure of from 125 to 130 millimetres of mercury, she would experience a rapid rise in pressure to 300 or 330 millimetres with headaches and a great sense of vascular oppression. The attacks might last a short time, come several times a day, or continue for several hours or a number of days. The patient had been so troubled for two years. I asked permission to explore the upper part of the abdomen, because in this area are many coördinated sympathetic structures. Making a surgical exploration in this case, I found within the peritoneal cavity no pathological condition other than increased venous congestion. At the upper left side through the posterior peritoneum was felt a rounded tumor, that lay anterior to the left renal vessels and adjacent to the left suprarenal gland. The posterior peritoneum was opened and the encapsulated tumor removed. The growth had many nerve connections which were torn loose, and the operative field was extremely bloody, as the posterior peritoneal veins were very large. Bleeding was

controlled only by packing. The patient made a complete recovery and now has been well with normal blood-pressure for more than five years.

Microscopical examination disclosed hyperplastic ganglionic nerve tissue, comprising a rounded, encapsulated tumor, with cells that appeared to be of a pre-malignant type.

Search of the literature disclosed reports of five post-mortem examinations of persons who had died after prolonged sickness, with similar symptoms of sudden and often repeated rise of blood-pressure. Three of these subjects were observed in France, and two in Germany; tumors were found at necropsy, involving sympathetic nerves and ganglionic structures along the spine, in the superior and inferior (particularly the middle) mediastinum, and the upper part of the abdomen. One case was similar to the case here reported. In four cases the tumors were malignant. Were they malignant in their early development? Probably not. Today, we believe the cancer cell is a secondary development on a previously exhausted or pathological cell.

Since Rowntree and I reported the case just described, two similar cases have been studied and the patients have been operated on in this country.

Scleroderma.—Adson, Brown and O'Leary have reported a number of cases of vascular disease of the skin, in which the patients have been relieved by operations on the sympathetic system. In describing the proper selection of cases for operation, he emphasized that the lesions should be symmetrical, and that the history should suggest chronic sympathetic overactivity.

Arthritis.—In 1928, Adson and Rowntree reported the effects of sympathetic ganglionectomy and ramisectomy in selected cases of arthritis. Later Hench and Craig found that the operation was most successful among patients with cold, clammy, sweaty hands and feet, whose symptoms were much relieved by heat. Adson, Henderson, and Hench have stated that, to secure the best results, the patients should be less than thirty-five years of age, and that the arthritis should be of the periarticular type, without changes in the articular ends of the bones; in a few selected cases, in which the patient was older, improvement has also occurred.

Diseases of Tubular Organs.—A few years ago, I endeavored to relieve pyloric spasm by section and separation of the nerves and mesenteric attachment above and below the pylorus, working through a circular incision through the muscle of the stomach, an inch and a half above the pylorus. In some, the acids were not changed, in others they were low after a considerable period. I cannot predict what would occur in enough of these cases to warrant continuing the use of the method. Mann, in his experimental work, showed that in order to affect the stomach, division of the nerves must be made above the diaphragm. This fact attracts our attention to cardiospasm, and we think of pylorospasm in its relation to ulcer, and as a secondary symptom in acute and functional diseases of the digestive tract. Spasm of the sphincter of Oddi, at the outlet of the common bile-duct, is certainly related to disease of the liver and of its system of ducts, and is probably an associated factor in the development of interstitial disease of the head of the pancreas and in disease of the gall-bladder. Removal of the gall-bladder

undoubtedly frees this sphincteric spasm and it should be practiced before the secondary and tertiary states develop, in which gall-stones add their mechanical problems.

Megacolon, or Hirschsprung's Disease.—Throughout many years, we have operated on patients with megacolon, or Hirschsprung's disease. Following the reports of Wade and Royle, concerning treatment of the disease by ramisectomy, Judd and Adson at the clinic performed lumbar gangliectomy and trunk resection in such a case, and secured complete relief; later they operated successfully in other cases. Morton and Scott, of Rochester, New York, proposed the use of spinal anæsthesia in selecting cases for operation; by interposing this temporary block between the bowel and the spinal cord the probable result of sympathectomy could thus be tested, and those cases in which evacuation of the bowel followed spinal anæsthesia could be chosen for operation.

Learmonth and Markowitz showed that the nerves in the pelvic mesocolon of the dog actively inhibit movements of the bowel, and that section of these nerves increased colonic peristalsis; they also showed that the internal anal sphincter is contracted by the action of sympathetic nerves. Applying these findings to man, Rankin and Learmonth have operated in a number of cases of megacolon; they have applied neurectomy to the pre-sacral nerve and the inferior mesenteric nerves; the results have been very satisfactory.

After division of the extrinsic nerves to relieve megacolon, there need be no fear of a paralyzed intestine, because the tubular viscera have intrinsic innervation which can be stimulated or depressed from without, just as the heart has the bundle of His. Alvarez has shown that the small intestine has so strong an innervation that if the intestine is removed from the body and kept in an ice-box for thirty-six to forty-eight hours, and then placed in warm Ringer's solution, it will start movement of the fluids within it, by peristaltic action, in the normal direction.

Urinary Retention.—Learmonth has shown that the pre-sacral (sympathetic) nerve causes relaxation of the bladder and closure of its outlet; in the presence of a weakened detrusor or motor muscle, and a great amount of residual urine, he has secured, by resection of the nerve, complete voluntary emptying of the bladder in four cases. Such conditions as those which Learmonth has relieved may arise from injury or severe infections in the lower part of the spinal cord, which reduce but do not wholly destroy the power of the pelvic nerves that are in control of evacuation.

In 1913, Latarjet and Bonnet made accurate dissection of the nerves to the lower part of the urinary tract. In 1921, Rochet published a paper in which he distinguished three kinds of pain in this region: (1) Lower ureteral colic; (2) painful contraction of portions of the bladder, and (3) pain due to lesions of the vesical sphincter. Impulses of pain arising from these causes are carried to higher levels of the spinal cord through white rami communicantes, which hook up the sympathetic system with somatic nerves. By section of nerves we may relieve the pain of those suffering from tuberculosis of the

bladder and hopeless cancer. I believe, too, that operations in this field may offer possibilities of relief in cases of so-called ureteral stricture of large calibre. I presented a paper on this subject at the Southern Surgical Association meeting in December of last year, because I believe that failure of repeated dilatation in some of these cases may be due to persisting sympathetic dysfunction. Incidentally, I would state the interesting fact that during menstruation and during the first three months of pregnancy the ureters are dilated, without any dilatation of the pelves of the kidneys.

Fearing I may have disturbed the equanimity of your belief with regard to the sympathetic nervous system, I will quote Fulton, concerning Cannon, the well-known physiologist: "Normally, in the sheltered existence of a laboratory, an animal has little occasion for emergency adjustments made by the sympathetic system, and Cannon has been able to show that an animal whose entire peripheral sympathetic system has been extirpated is able to exist without difficulty so long as it is not exposed to extremes of temperature or to any other relatively severe condition which would require a struggle for existence."

*Sympathetic Ganglionectomy and Ramisectomy Performed at
The Mayo Clinic to May 1, 1932*

Raynaud's disease	115*
Thrombo-angiitis obliterans	193†
Scleroderma	29‡
Arthritis	92§
Hypertension	4
Megacolon	13

* 56 of the operations for Raynaud's disease were bilateral

† 93 of the operations for thrombo-angiitis obliterans were bilateral

‡ 14 of the operations for scleroderma were bilateral

§ 46 of the operations for arthritis were bilateral

|| 5 of the operations for megacolon were bilateral

CARCINOMA OF THE MOUTH AND TONGUE

BY JOHN FRASER, M.D.

OF EDINBURGH, SCOTLAND

CARCINOMA of the mouth has the interest which attaches to an always serious and often fatal disease, its pathology has many points of alluring significance, while the problem of its treatment presents many difficulties.

It is, I think, appropriate that I should introduce the subject with a reference to the incidence of the disease in Scotland. The Registrar General has kindly put certain figures at my disposal, and their summary is as follows. The population of Scotland at the present day is 4,780,000, and of that total the number of males is 2,325,867. Taking a still more selective group, that of males above the age of forty years (the period in which the great majority of tongue- and mouth-carcinoma cases occur) we find that it presents a total of 702,000 individuals. This is the field—the yield is more difficult to estimate, but this we know, that during the decade 1920–1929 a total of 3,291 persons succumbed as the result of carcinoma of the buccal cavity. This is a mortality figure; it is therefore a conservative estimate of morbidity, but it is the only accurate summation at present available. The information indicates that some 330 cases die in Scotland each year from the disease. The figure does not seem unduly large, and I have been unable to secure evidence as to how it compares with the incidence in other countries.

PATHOLOGY.—*Normal Buccal Epithelium.*—It has been my intention to treat the subject on pathological rather than on statistical lines, and therefore I would now ask you to review with me the epithelial arrangements as they exist within the cavity of the mouth.

Buccal epithelium is arranged on a uniform plan. It is true that in certain situations there are special arrangements, as we shall presently see, but the general picture presents a basis of similarity. If we examine the mouth cavity of a 35-millimetre fœtus (Fig. 1), we find that the epithelial lining is composed of a single layer of cubical epithelium. The cells are uniform in shape and in size, the cytoplasm contains a large number of granules, and the nuclei are in process of repeated mitotic division. It is from this source that the fully developed epithelium of later life is developed. By a process of division and some degree of cell differentiation an arrangement is produced by which the cell lining is grouped in four super-imposed layers.

Considering the arrangement in more detail, the deepest layer (Fig. 2) resting upon the sub-epithelial basement membrane retains many of the characteristics of the primitive fœtal type of epithelium. The cells are cubical in outline, the cytoplasm is loaded with basophilic granules, the nuclei are hyperchromatic and constantly dividing (Fig. 3); the entire layer is usually a single, occasionally a double row in thickness, and, as I have said, its similarity to the primitive type of epithelium is very striking. Overlying this arrangement and derived from it we find a distinctive and highly interesting distribution. These are the cells of the prickly group; they are larger than their progenitors, in shape they are somewhat fusiform, the nuclei are large and active, with distinct nucleoli, but the real distinction of the cell is the acquisition of prickles. These interesting and no doubt

CARCINOMA OF MOUTH AND TONGUE

important structures pass like stays or bridges across the intercellular spaces to be continuous with the cytoplasm of opposing surfaces. It is significant that in virtue of the prickles the intercellular spaces are wider in this second layer than in any other portion of the epithelial arrangement.

What purpose or purposes do the prickles fulfil? Probably two. To some extent they hold the cell in position, while protecting it from undue pressure by the surrounding

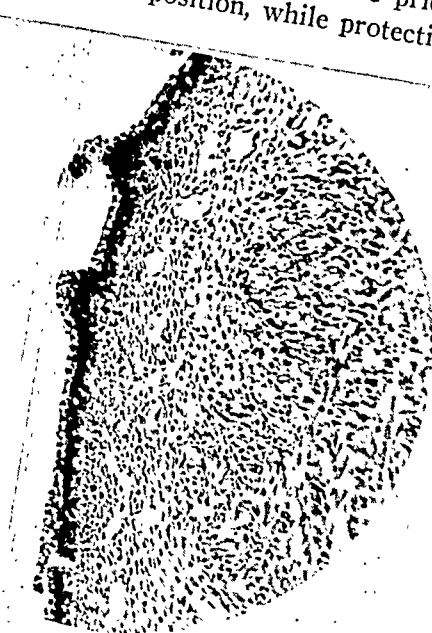


FIG. 1.

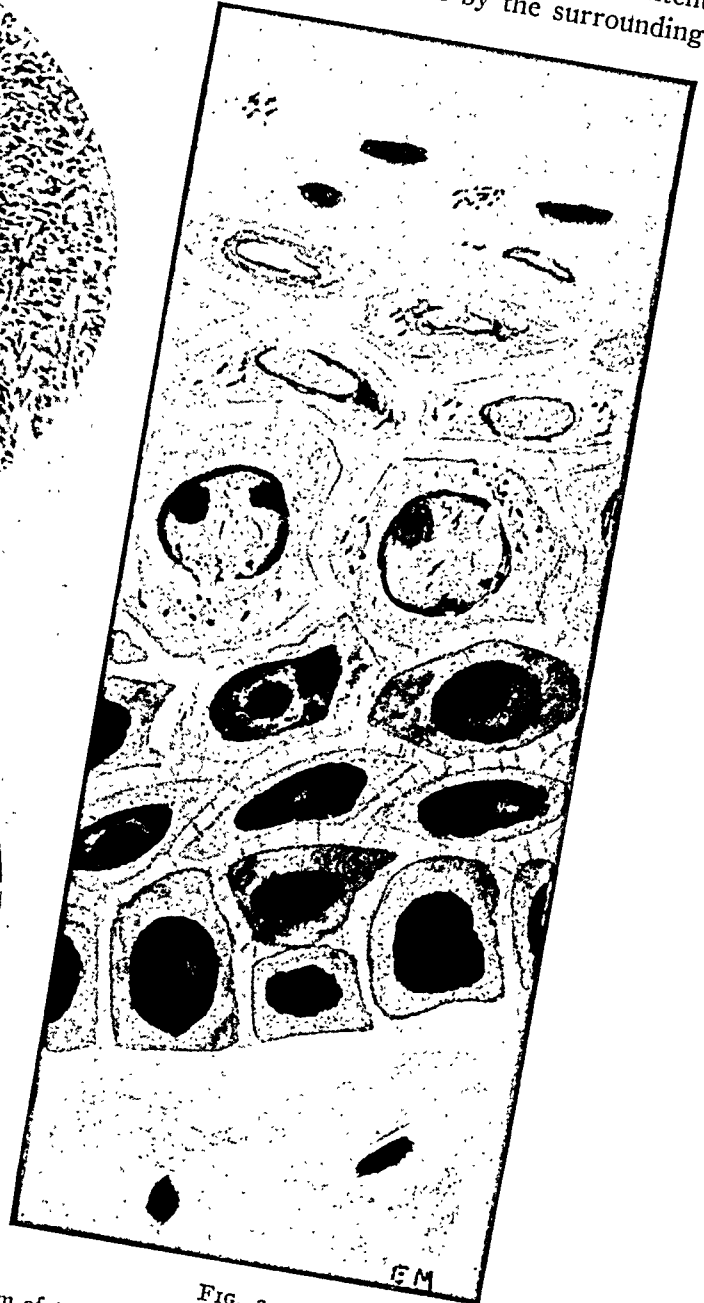


FIG. 2.

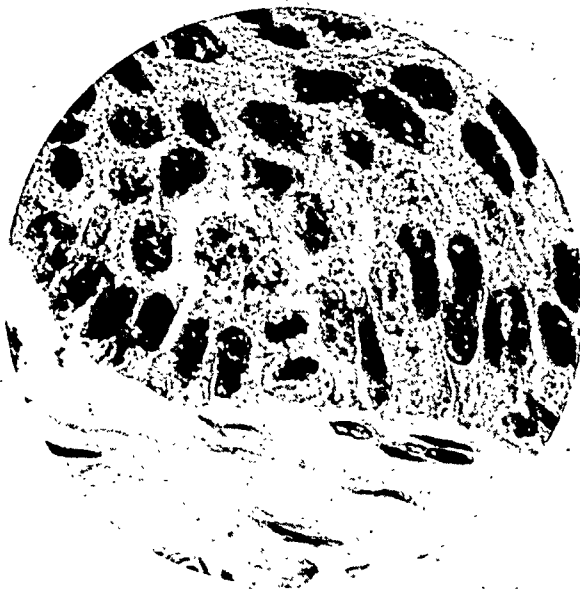


FIG. 3.

FIG. 1.—Thirty-five-millimetres Embryo. Section of dorsum of tongue showing primitive epithelium.
FIG. 2.—Diagram of cell layers in normal squamous epithelium.
FIG. 3.—Photomicrograph of normal epithelium showing mitosis of cells of basal layers.

cells, but a function of greater importance is the part which they play in maintaining a sufficiency of intercellular space in order that lymph may circulate. It would seem that, in order to maintain health and nutrition, each cell of the prickle layer shall be maintained in what is virtually a lymph bath, and it is in virtue of the prickle that this essential is achieved.

Overlying the prickle layer there is a cell group showing sufficient distinction and peculiarity to justify its recognition in a special class. Though derived from the prickle

layer, these cells possess individual characteristics. The prickle has disappeared, the intercellular spaces have accordingly vanished, and, in virtue of pressure influence, the cells have acquired a flattened and elongated outline. There is increased permeability of the cell membrane, the nuclei have degenerated, and now and then the process of nuclear rupture with escape of the chromatin may be witnessed. The phase of degeneration is further evidenced by the appearance in the cytoplasm of keratin or eleidin granules.

What is the explanation of the change? That it is degenerative in its issue is clear, but what is the feature which precipitates the alteration? It has been suggested to me by Mr. Eric Mekie, and I think he is correct, that the deciding influence is a cutting off of the lymph flow, the result, if you care to put it so, of the disappearance of the prickles, for as the intercellular space lessens, the lymph circulation is correspondingly diminished, and, as the cell nutrition is entirely lymph-maintained, an impoverishment of nutrition means cell degeneration. In the superficial or surface layers the degeneration is complete—the nucleus as such has disappeared, the chromatin is dissipated, keratin deposit (the stigma of degeneration) is abundant, and it is as dead cells that the individual elements of the superficial layer are finally dispersed.

Such are the arrangements of healthy buccal epithelium, and certain features of that arrangement must, I think, impress us, such as the evolution of the various cell elements from a common progenitor, the part which the lymph plays in maintaining the healthful nutrition of the cell, and the natural degenerative sequelæ which follow when the lymph nutrition is disturbed.

Accepting this as the general scheme upon which buccal epithelium is planned and arranged, we ask ourselves: "Is the scheme universal, or are there modifications or adaptations in different parts?" The question is of more than simple inquisitive interest, for it may be that the answer will affect our conception of the distribution and possibly of the etiology of disease. My point is this. It has been our experience that, where carcinoma of the mouth is concerned, there are sites of election, areas in which a preponderance of disease is evident, and I am curious to know whether in these special localities there are structural peculiarities which might in some measure explain an undue liability to disease. An analysis of the figures which have come under our notice indicates that the sites (Fig. 4A and B) within the mouth most frequently affected by malignant disease are:

- (a) The anterior two-thirds of the tongue (43 per cent.)
- (b) The palato-glossal sulcus (20 per cent.)
- (c) The gingivo-glossal sulcus (11 per cent.)
- (d) The mouth floor (10 per cent.)

The remaining 16 per cent. appears to show no constancy of site occurrence. It seems reasonable to investigate the histological characteristics of these regions, and I propose to present a summary of our conclusions.

The Anterior Two-thirds of the Tongue.—These areas show no outstanding variation of structure. The picture is that which I have already described as being characteristic of buccal epithelium in general. It is true that at the edge of the tongue (Fig. 5), a site showing a high percentage of morbidity—68 per cent.—we find a variation in so far as the thick epithelium of the dorsum merges at this point into an epithelium which is thinner and more

"papillated" in arrangement, but this is a variation which scarcely justifies individual recognition, and we cannot say that there is any structural peculiarity in this region which might predispose the part to morbidity.

The real interest, so far as the tongue is concerned, is to decide whether there is any structural explanation of the apparent immunity to disease which is enjoyed by the posterior third in contrast to the anterior two-thirds. I anticipate that any claim to immunity may be questioned, but, so far as we have been able to discover, primary disease of the posterior third of the tongue is a rare event. I have used the term "primary" because I wish to make it clear that I do not include examples of disease which extend into the posterior third of the tongue from such surrounding parts as the palato-

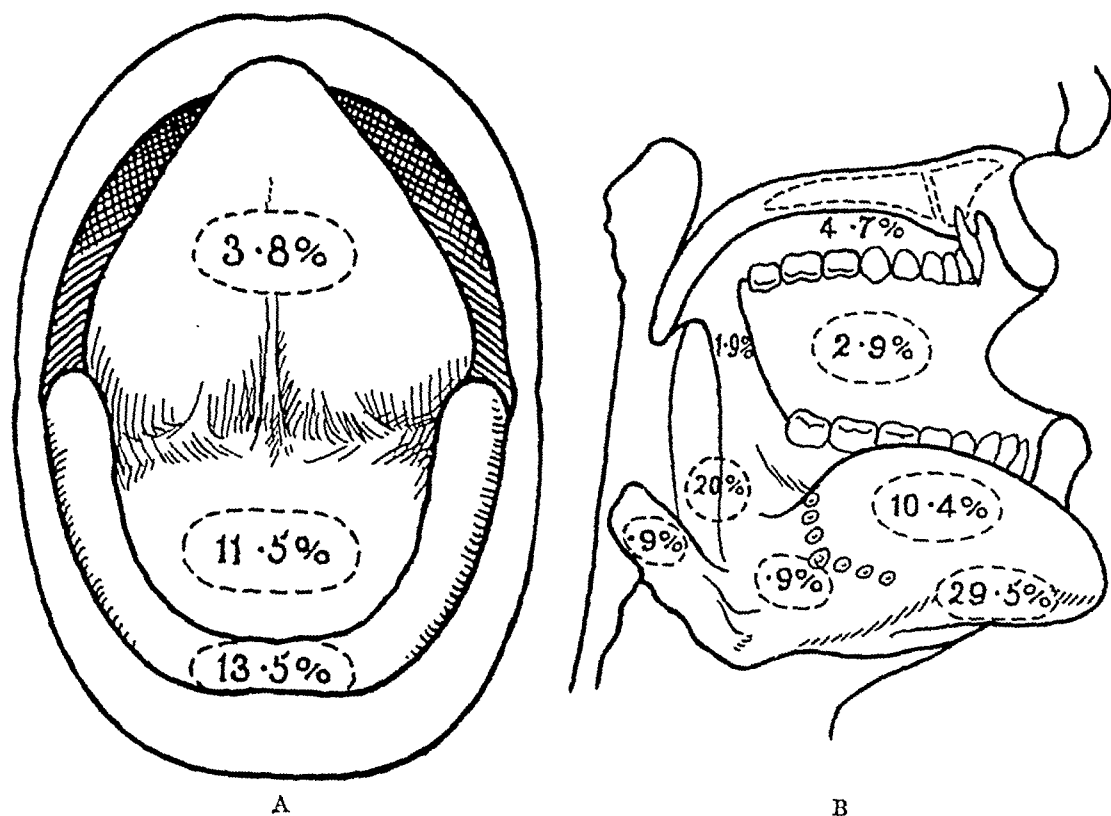


FIG. 4 A and B.—Site incidence of malignant disease of the buccal cavity.

glossal region, the valliculæ and the epiglottis. Observing this distinction, in forty-seven cases of primary tongue carcinoma in one instance only did the disease originate in the posterior third. The actual distribution of disease in the forty-seven cases may be of interest, and therefore I give it.

In thirty-two instances (68 per cent.) the disease appeared at the tongue edge. In fourteen instances (29 per cent.) it developed in relation to the dorsum. In one instance only was the posterior third affected. Such a relative degree of immunity must have an explanation. I do not say that structural peculiarities afford that explanation, but it is significant that the posterior third (Fig. 6) has certain distinctive points as compared with the anterior two-thirds, and they are as follow:

- (1) The sub-epithelial area contains a proportion of lymphoid tissue.
- (2) The epithelial layer is relatively thin.

- (3) Keratinization is imperfect and there is no definite keratinized surface layer.
- (4) The prickle-cell layer is deficient or even entirely absent.
- (5) The deep granular layer is well developed.
- (6) There are numerous racemose glands in the sub-epithelial space.

The question whether or not the relative freedom from morbidity is due to one or more of these structural distinctions cannot be answered with any measure of assurance, but there are certain possibilities which suggest themselves. I believe, for example, that the existence of lymphoid tissue in this area affords a measure of resistance to a malignant epithelial change. We have a great deal to learn about the part which the lymphocytes play in resisting malignant epithelial invasion. It is certain that a lymphocyte-cell barrier surrounds the early infiltration of a malignant epithelial cell. Another feature which may lessen the tendency to morbidity in this situation is the relative absence of cell differentiation, the tendency being for the cells to remain as the primary cubical and granular type rather than to acquire the differentiating features of prickle and keratin. This, however, is mere hypothesis, and we have no definite knowledge of the tissue factors as they affect morbidity.

The Palato-glossal Area.—I have alluded to the fact that 20 per cent. of buccal carcinomata originate in the palato-glossal area. There is reason to believe that this high proportion is to some extent explained by peculiarities of structure which may be predisposing to disease. If we examine that portion of the tongue edge (Fig. 7) which comes into contact with the anterior pillar of the fauces, we find certain indistinct vertical ridges of epithelium (the papilla foliata). They are the remnants of a structure which reaches its fullest degree of development in rodents and the lower primates, a multiple crypt-like arrangement the walls of which are provided with numerous taste buds (Fig. 8), so that the flavor of food held in the hollow of the cheek is fully appreciated. In man the structure is an atavism—the taste buds have disappeared, but the crypts remain, so that large numbers of epithelial cells without any definite or specified function are grouped within these confines. The fact that collections of these cells may be almost entirely cut off from communication with the surface probably adds to the potentiality of danger. It is believed that cells of this type and under such conditions are frequent sources of malignant change (Fig. 9) and, if we support this view, we may well agree that the relatively large percentage of malignant morbidity in this area owes part of its incidence to predisposing structural peculiarities.

The Floor of the Mouth.—In this region of the mouth 10 per cent. of carcinomata occur, and on a closer analysis it is evident that the majority of these are localized around the openings of the salivary ducts (Fig. 10). Such localities bespeak junctional epithelium, and it is possible that in this structural peculiarity we find at least one etiological factor.

CARCINOMA OF MOUTH AND TONGUE

Fig. 5.—Edge of tongue.



Fig. 6.—Dorsum of tongue in posterior third.



Fig. 7.—Rabbit's tongue.



Fig. 8.—Rabbit's tongue. Folia linguae showing taste buds.

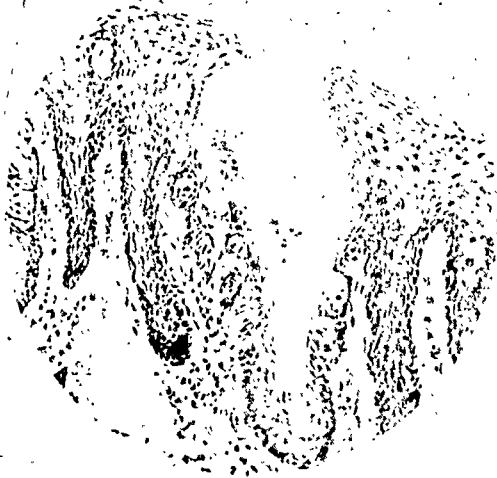


Fig. 9.—Folia linguae.



Fig. 10.—Duct of mucous gland in floor of mouth.



The Gingivo-glossal Sulcus.—Here there is no evident factor of special tissue arrangement. The epithelial arrangements are uniform and complete, and it is evident that the etiological factor which individually affects this region is something apart from any structural peculiarity.

I would sum up this whole matter of epithelial arrangements by saying that in two situations—the palato-glossal sulcus and the floor of the mouth—we find conditions of cell distribution such as may constitute predilection to neoplasm, while in the posterior third of the tongue the tissue arrangements

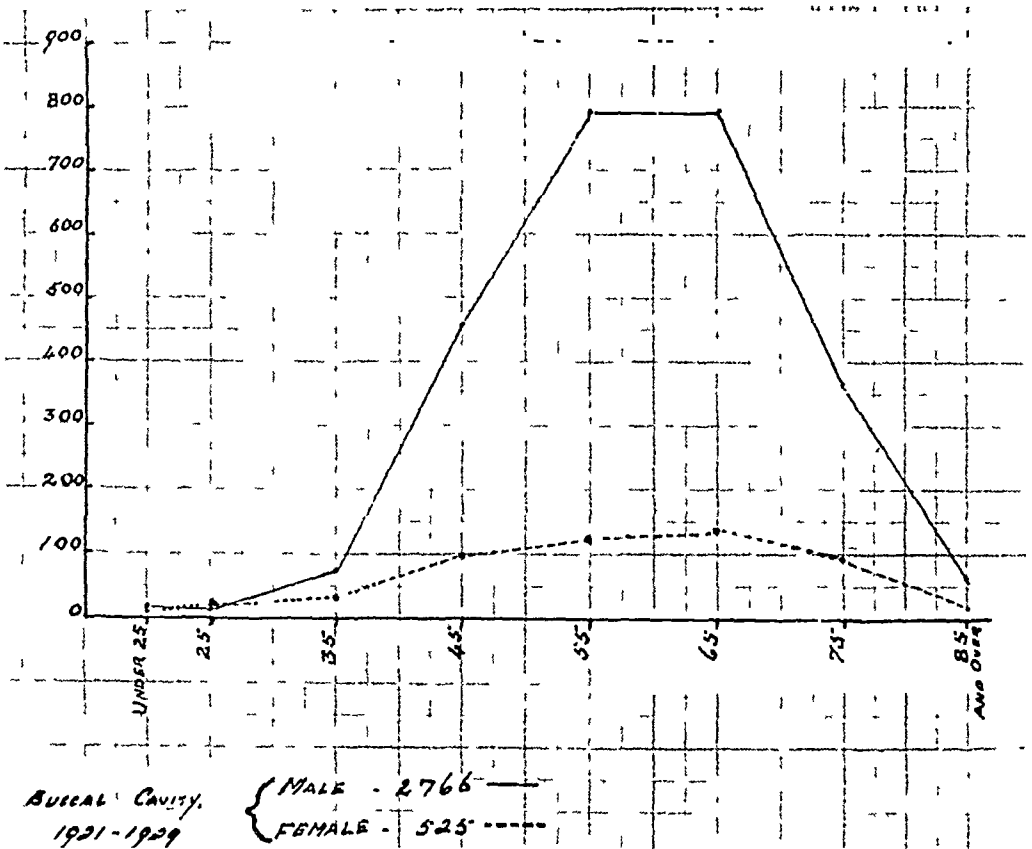


FIG 11—Age incidence of buccal carcinoma. (Scotland)

are such as may confer some degree of unusual resistance of the parts to such a change

If such structural peculiarities as I have outlined play a part in the site incidence of mouth tumors, there are other influences which act as the stimulus in the production of the erratic cell growth which constitutes malignancy. Let me review such influences as may seem to play a part in the so highly debatable problem of etiology.

Age is the first consideration, and it has this importance that as the years advance the liability to the disease appears to increase, so that the maximum incidence occurs in the decade between seventy-five and eighty-five years (Fig. 11). It is obvious that the proportion of individuals who reach such an age

CARCINOMA OF MOUTH AND TONGUE

is relatively small, and in any estimate of the proportional occurrence of the disease this fact must be taken into account, but, when various corrections are made, it is evident that with increase of age there is increased liability to the disease. The explanation of age influence is debatable (Fig. 12), but in all likelihood it may be taken as meaning that cell instability increases as age advances, so that a stimulus which in younger tissue would pass unnoticed now induces the change that results in malignancy.

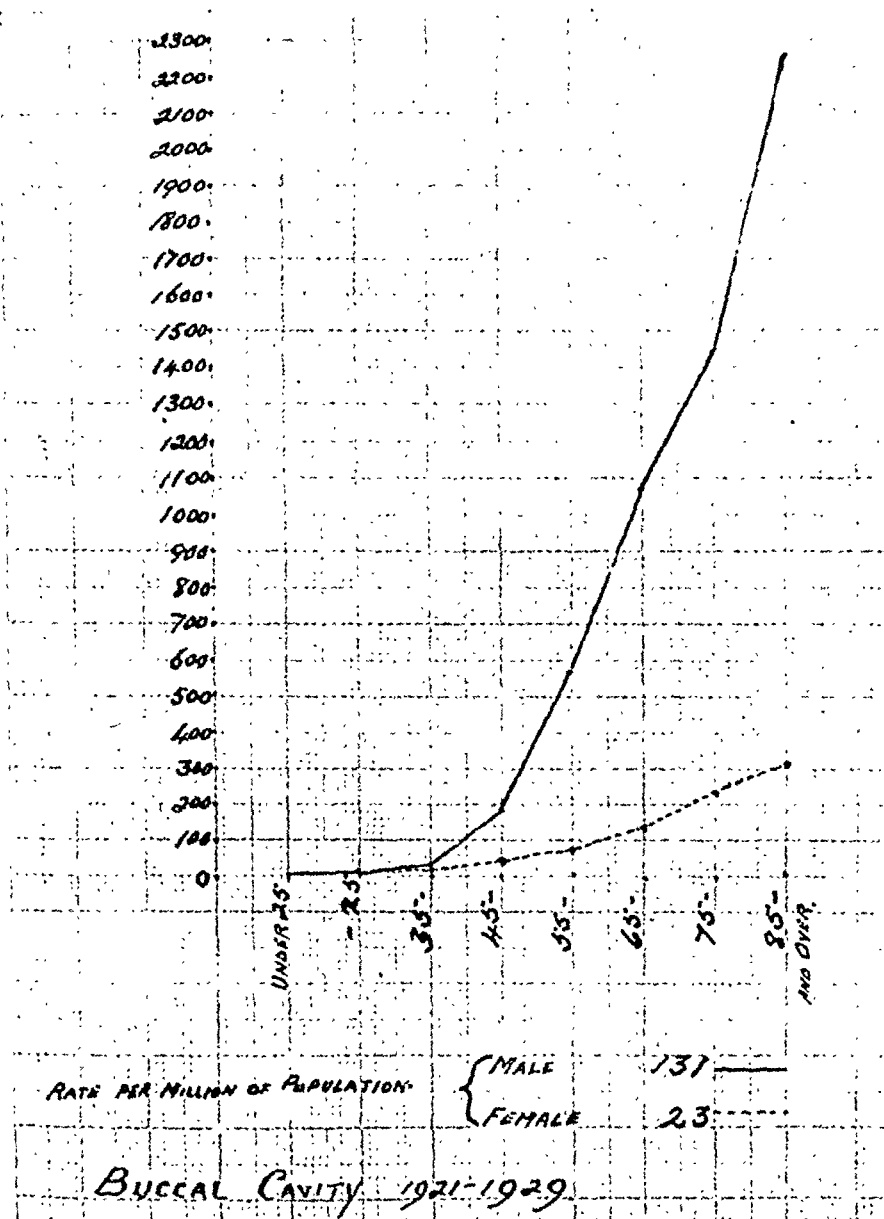


FIG. 12.—Age incidence of buccal carcinoma. (Scotland.) (Corrected.)

Secr.—It is common knowledge that mouth carcinoma is more often met with in males than in females in a proportion of eight to one, and it is agreed that the higher sex incidence of the male is explained by the greater degree of injury which he inflicts upon his buccal mucous membrane by such irritants as spirits and tobacco. Confirmation of this would seem to be supplied by statistics from Southern India and Ceylon, where the incidence of buccal

carcinoma is greater in females owing to the fact that they indulge in the habit of chewing betel, a combination of tobacco, areca nut, and slaked lime. There is the further factor that the average female is probably more careful about her teeth and mouth hygiene, and in so much she preserves herself from the irritation and stimulus of infection.

Heredity as an influence is a matter which I shall not discuss because I have not sufficient knowledge to assess its importance, but I would like to record an experience which suggests that an indirect heredity—the transmission of an enhanced liability to the disease—may exist. Three brothers, A, B, and C, living under different conditions, developed buccal carcinoma, and all three cases appeared within a period of two years. Their father, an uncle, and an aunt had succumbed from epithelial carcinoma. The coincidence is suggestive, but its exact significance must for the present remain in doubt.

Syphilis has long been recognized as being in some way intimately associated with the development of mouth carcinoma. Literature contains abundant references on the question, and Poirier once expressed his views in the somewhat cryptic phrase that "Cancer of the tongue is a disease of syphilitic smokers." In a recent analysis of seventy cases of mouth carcinoma we have found that 14.7 per cent. afforded evidence of a former syphilitic infection. This is a smaller proportion than is usually recorded, but the real interest of the analysis lies in what might be regarded as a secondary point. If we estimate the proportion of syphilis in relation to the site at which the carcinoma occurs we find that in tongue carcinoma the syphilitic proportion is 42.3 per cent., and where the malignant disease affects the dorsum of the tongue the syphilitic incidence rises to 78.3 per cent. What is the explanation? It may be that the vascular changes of a syphilitic infection are more fully exercised in the tongue dorsum than in other situations, but there is evidence to show that the association is certainly related to the condition of leucoplakia. Dorsal tongue leucoplakia is one of the most frequent associations of former syphilis, and in 90 per cent. of cases, dorsal tongue carcinomata are preceded by leucoplakia. The close relationship between dorsal tongue carcinoma and syphilis thus seems to be established.

Tobacco as an etiological influence is difficult to estimate. What would seem to be a convincing statement of its importance is found in Turner's report to the British Colonial Office in 1905 on the incidence of buccal carcinoma among the Spaniards of Gibraltar. In our series (105 cases) we have to record that in eighty-eight male cases sixty-five were heavy pipe smokers, and of the remaining thirteen there was no individual who was a rigid non-smoker. Of tobacco it may be said that the drug (if I may call it so) in itself does not produce the disease, but in conjunction with one or more irritants of a general or local type, it may be a factor in inducing the cell changes which result in malignancy.

Alcohol, and particularly raw spirit, is probably rightly regarded as an important factor in the production of the disease. Figures furnished by the Registrar-General of Scotland indicate what I might term the geographical distribution of mouth carcinoma. In two countries the incidence figure is unduly high, and it is significant that these are areas in which the drinking of raw spirit is prevalent. It is probable that the influence of alcohol on tissue change is twofold; in part it is a surface irritant, in part it acts as a circulatory toxin, at first stimulating tissue growth, later inducing a degenerative change on the tissue it has previously stimulated, and it is not surprising that, when imbibed in a concentrated form, it plays some part in the production of carcinoma. In the series which forms the basis of this paper (105 cases), twenty were admittedly heavy spirit drinkers, but it is obvious how difficult it is to obtain accurate information on such details, and the proportion may well have been higher.

Mouth infection is in our view the most constant and prevailing associated influence, and we have no doubt that it plays a highly significant part in the production of the malignant error. An analysis shows that at least 50 per cent. of the cases were infected with pyorrhoea alveolaris prior to the development of the cancer, and from what we have seen we are satisfied that this influence is one of the most significant in the etiological picture, that it is the most constant and common factor, and that its influence is increased when it is combined with other irritant factors such as alcohol, tobacco, syphilis, or direct local irritation. It is probable that, as in the case of alcohol, the effects of infection are exercised locally and generally.

Direct Local Irritants.—It is an accepted truism that local irritants in any shape or form influence the production of carcinoma and in the sensitive and almost unstable epithelium of the mouth the principle has peculiar importance. The series of cases under review has many examples illustrative of this. The sharp-edged tooth and the ill-fitting denture were recorded in several instances; in two cases the disease began in the mucous membrane of the alveolus contiguous with a tooth-filling which, occupying the lowest part of the tooth, came into contact with the epithelium. It is probably more than a coincidence that in both cases the filling was found to contain an element which I understand is unusual in dental therapeutics—antimony.

In conjunction with this it is well to record the occurrence of a carcinoma of the tongue in an antimony worker aged sixty-three years (C835). He acted as an antimony "feeder" for seventeen years (1898–1915). In the later years of his service he developed an eczematous condition of the forearm, a pronounced hyperplasia of the palmar skin and a buccal leucoplakia. It was the development of these errors which induced him to abandon his work. He came under our care in 1925, suffering from a carcinoma of the tongue. It is necessary to add, for it may indicate the influence of superimposed irritants, that he was a heavy smoker, and showed a strongly positive Wassermann reaction.

In two instances tar irritants may have been the responsible factors. One case worked in the fumes of tar paper (Eg19, aged sixty-three years). He developed a carcinoma of the lower lip, and eighteen months later an epithelioma on the buccal surface of the cheek on the opposite side. The other was a roadman tar sprayer (A840, aged sixty-three years), who developed a carcinoma on the buccal surface of the lower lip.

I must add that where carcinoma of the mouth is concerned we find evidence of a tendency which, though no doubt manifest in malignant disease elsewhere, is particularly noticeable in carcinoma of the buccal epithelium. I allude to the liability which there is in certain individuals to what may be termed epithelial instability, the tendency for a malignant change corrected at one point to reappear at subsequent dates in other situations within the mouth. There were five examples of this tendency in our series of 105 cases, and the facts regarding the occurrence may be summarized as follows:

A. suffered fourteen years ago from an epithelioma of the lower lip—he has recently been under treatment for a cancer of the right palato-glossal fold (B283); B. was affected with a rodent ulcer of the left nostril twelve years ago—there is now a cancer of the left palato-glossal fold (A953); C. developed an epithelioma of the lower lip fifteen years ago—six months ago cancer appeared in the left edge of the tongue (A810); D. developed an epithelioma of the left side of the tongue in 1916—eight years later a similar tumor appeared on the right side of the tongue, which was successfully treated, but two years later there was a further development (B568); E., affected with an epithelioma of the left lower lip, developed the same condition in the buccal surface of the right cheek seven months later. It is significant that in four out of the five cases the time intervals between the occurrence of disease were fourteen, fifteen, and eight years respectively. It is difficult to assess the importance which should be attached to this observation. Is it an indication of an inherent instability of buccal epithelium? Is it a response to a persisting etiological influence or is it merely a coincidence? Its significance in the life history of the individual is apparent.

These are some of the factors which a study of the etiology would appear to bring out. There are certain localities within the mouth which in virtue of structural peculiarities appear to have a predisposition to epithelial instability, and it is possibly this association which explains the high incidence of the disease in these situations. There are factors which act as direct local irritants of the surface epithelium, such as the mechanical influence of the ill-fitting denture, the chemical stimulus of alcohol, of tobacco, and of dental sepsis. There are factors of a more general influence, syphilis and alcohol, which, brought to the tissues through the medium of the blood and the lymph-stream, induce a tissue change at first stimulant, later degenerative, which probably plays an important part in inducing the neoplastic change. Underlying these individual and specific influences there are the more intangible

factors of inherent cell instability and the degenerative changes which appear to be natural sequelæ of advancing age. The etiological factor in an individual case may be any one of these influences, and in all likelihood a combination of influences plays a part in the majority of instances.

The Pathology of the Lesion.—When we consider malignant disease of the mouth from the pathological standpoint it is convenient to group the lesion into two classes: (a) Those which demonstrate a uniform type of pathology, commonly known as the *epitheliomata*, but which from cytological and morphological considerations are more accurately termed *acanthomata*; and (b) a group of tumors the pathology of which has features quite atypical of the changes one associates with buccal epithelium. Tumors in the second group are rare; their individual characteristics, clinical and pathological, vary with each type. There is much of interest in their several distinctions, and, if time permits, I shall allude to them later, but for the present let us visualize the sequence of events as it is pictured in the characteristic and common epithelioma or acanthoma.

There is, I think, general agreement that the cell which invades the sub-epithelial area is one of the cubical and basement cell group. That is the view expressed by Broders, Ewing, and by Mekie, and, when we consider the question, it is difficult to see how it could be otherwise. It is evident from the study of the normal epithelial arrangements that the basal cell is the one which is endowed with the capacity of mitotic division; in fact, it is possible that it is the only cell of the buccal epithelial group which is so endowed, the other cells being offspring which themselves are incapable of independent division, but which pass through a life cycle of varying adaptation of form. If this is the correct conception, and there is much to be said in favor of it, we must believe almost of necessity that the basement cell (Fig. 13) is the originating factor in the histogenesis of the epithelial tumor.

Let us trace the further evolution of the cell changes (Fig. 14). Whatever the stimulus may be which leads to the change, there is a migration of the basement cell through the sub-epithelial membrane into the sub-epithelial tissues. The advance takes place in a variety of ways—in lines of infiltration spread, in rounded club-shaped cell groups, in a uniform mass invasion. Different types of invasion may exist in the same tumor (Fig. 15), but as a rule there is a degree of uniformity in individual tumors, so much so that the type of cell invasion can often be surmised from the clinical appearance of the tumor, the fissured epithelioma indicating the narrow infiltration spread, while the nodular tumor is likely to be associated with the mass type of invasion.

Invasion having occurred, what is the further progress of events? In what may be considered characteristic circumstances the cellular changes pass on to cell-nest formation (Fig. 16), and when we investigate the process we find that the metamorphosis we are witnessing is a reproduction of the process we have already witnessed in normal epithelium. This is a remarkable finding, and there are comparatively few parallels in histopathology. As



FIG. 13—Origin of acanthonata. Down growth of basal cells.



FIG. 14—Method of down growth. Strand formation.



FIG. 15—Method of down growth. Club formation

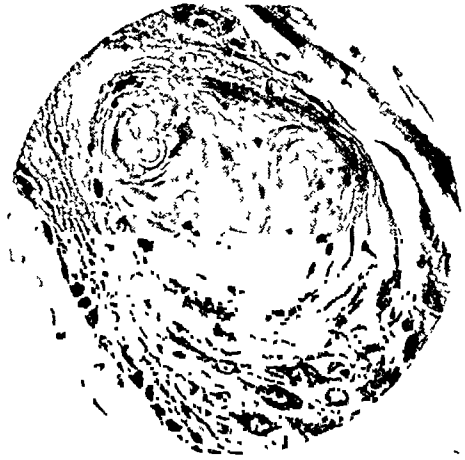


FIG. 16—Structure of cell nest.

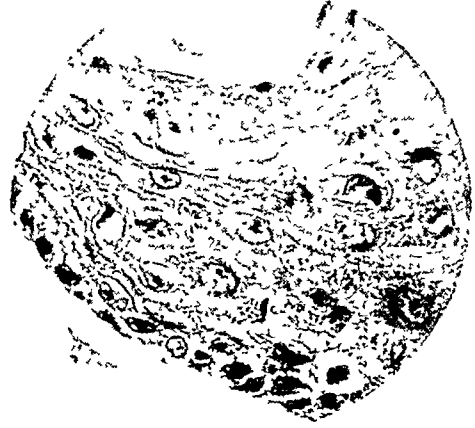


FIG. 17—Cell layers in a cell nest.

CARCINOMA OF MOUTH AND TONGUE

we trace the invading cubical cells we find that they tend to arrange themselves in concentric groupings. Those at the periphery show abundant protoplasm of a granular and basophilic type, while there is abundant mitosis of the deeply staining nucleus. More centrally the cells are fusiform in outline, they are provided with prickles, and they lie tangentially to the central axis of the group. The protoplasm is swollen in appearance, and shows an eosinophilic staining reaction, while the nucleus has increased in size. Still more centrally, the nuclear membrane ruptures, its chromatin passes into a

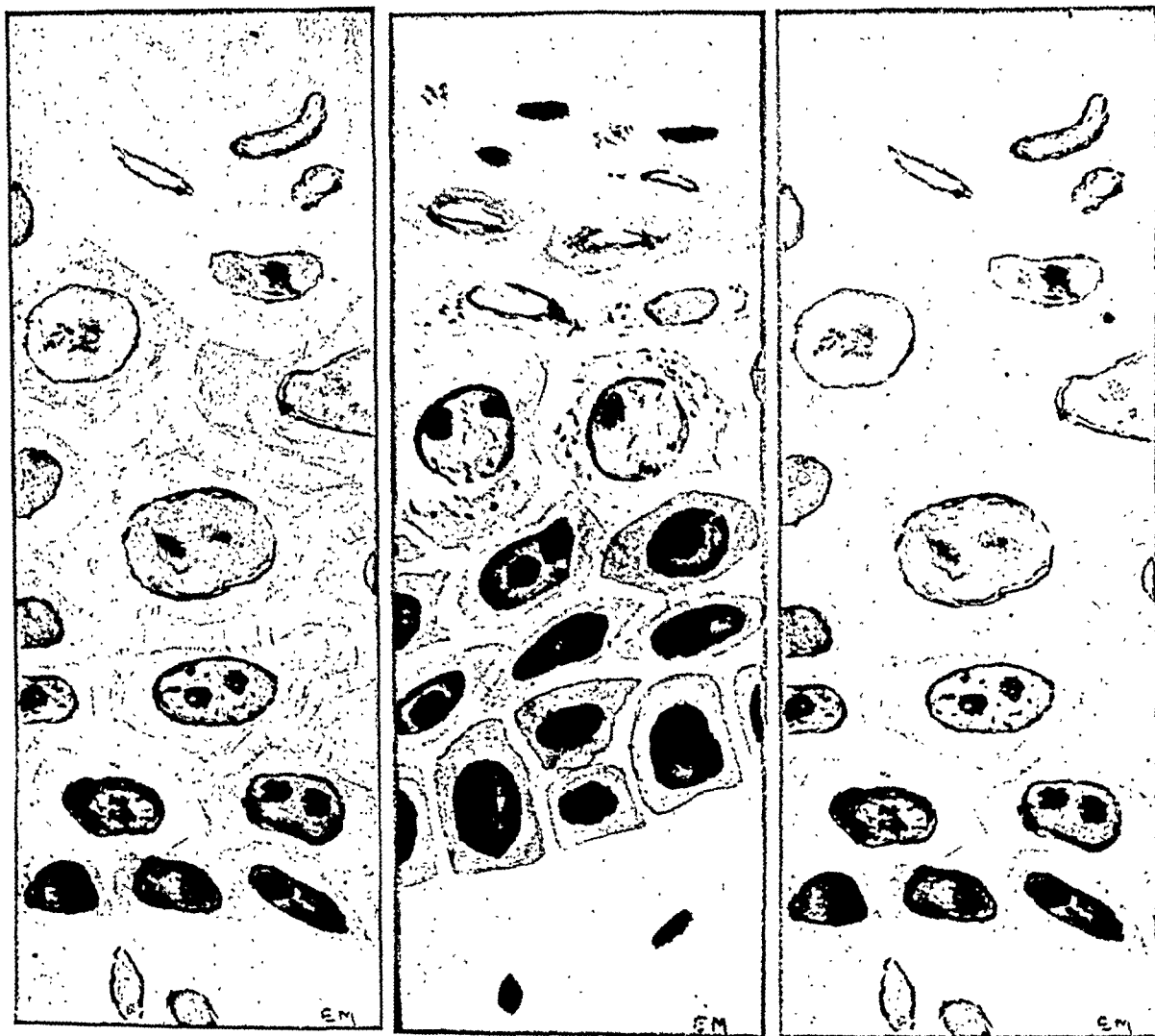


FIG. 18.

FIG. 19A.

FIG. 19B.

FIG. 18.—Diagram showing cell layers in acanthoma.

FIG. 19 A and B.—Comparison of cells of normal epithelium and those of cell nest.

cytoplasm which is now a homogeneous structureless mass, and it is the concentric whorl-like arrangement of this substance interspaced with fragments of nuclear membrane and chromatin debris which gives the appearance of the cell nest (Fig. 17). What we have witnessed has been a metamorphosis of the cell from cubical basement epithelium to the stage of complete keratinization, circumstances of position and of tissue tension having resulted in striking alteration in cell arrangement, but the change is a reproduction of a

natural process under altered conditions, and for that very reason assuming features of pathological significance (Fig. 18).

While these are the changes which we regard as characteristic of a malignant degeneration, typifying as they do the successive stages in the life history of the cell (Fig. 19), we must recognize that in many instances the process is not carried to such an ultimate sequel, that it may be arrested at varying stages of the process. It may be that the tumor is constituted by cells of the cubical type, and that no variation from this can be discovered; on the other hand, the evolution may extend to the stage of the large, flat, squamous cell, the prototype of the prickle cell; while in a third group (and they constitute the majority) the variation presents the complete picture of cell distinction from cubical epithelium to full keratinization. It has been suggested by Broders that the term "differentiation" is that which most fully expresses the changes which the cell may undergo.

It is appropriate at this stage to make allusion to the work of Broders on the subject of the differentiation in so far as it may affect the malignancy of the tumor and the prognosis of the individual. Broders recognizes four grades of tumor type according to the degree of differentiation of the cell. He accepts cell-nest or pearly-body formation as the standard of complete differentiation, the large, flat, squamous cell with small nuclei and early keratinization as indicating partial differentiation, while the cubical cell represents an undifferentiated state. On this basis he groups the cell incidence in the various grades as follow (Figs. 20, 21, 22 and 23):

<i>Grade I</i>	{	Differentiated, 75 per cent.
	{	Undifferentiated, 25 per cent.
<i>Grade II</i>	{	Differentiated, 50 per cent.
	{	Undifferentiated, 50 per cent.
<i>Grade III</i>	{	Differentiated, 25 per cent.
	{	Undifferentiated, 75 per cent.
<i>Grade IV</i>	{	Differentiated, 0 per cent.
	{	Undifferentiated, 100 per cent.

Such a classification or grouping has certain significance. It is of value for descriptive purposes, and the conception which it implies has a certain scientific merit, but it is as an index of the clinical state that its most significant application lies, for it would seem beyond dispute that it is in the undifferentiated type that the greatest malignant potentiality exists.

We have analyzed the tumor types in our series on the basis of Broders' classification, and the results may be indicated as follow:

<i>Group</i>	<i>Percentage</i>
I	48 per cent.
II }	
III }	36 per cent.
IV	16 per cent.

The Influences Which Control Differentiation.—It is reasonable that we should ask ourselves: What is the factor which controls the variation in



FIG. 20.—Squamous epithelioma.
Type I.)

(Broders



FIG. 21.—Squamous epithelioma.
Type II.)

(Broders

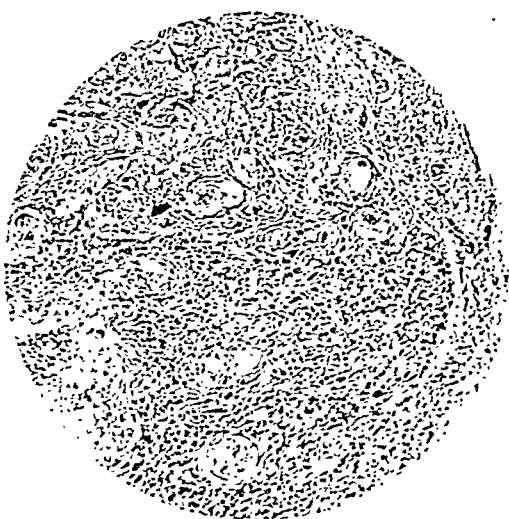


FIG. 22.—Squamous epithelioma.
Type III.)

(Broders



FIG. 23.—Squamous epithelioma.
Type IV.)

(Broders



FIG. 25.—Intense lymphocytic reaction to
tumor.



FIG. 26.—Fibrous reaction to tumor.

differentiation in these tumors? (Fig. 24.) It may be that it is a matter of inherent variability in the cell, an influence which is too indefinite and intangible to permit of definition, but on the other hand there are indications that the explanation is a demonstrable one. It will be recalled that the variation in normal epithelium may depend upon nutritive factors; the cubical basement cell produces the large prickly one, a cell which is bathed in lymph, and which maintains its vitality by a process of absorption from the lymph (Fig. 25); as we approach a more superficial level the lymph circulation is either lessened, or its efficiency curtailed, with the result that degenerative changes appear and keratinization ensues. (Mekie.) If this be the normal process of events, it is not unreasonable to argue that the variations encountered in tumor formation have a similar explanation (Fig. 26). If nutrition is maintained when the basement-cell invasion occurs, the likelihood is that the characters of a cubical-celled tumor will be demonstrated; if, on the other hand, nutrition is imperfect, the various processes of differentiation or of degeneration appear, until the full keratinization of cell-nest formation is

Lymphocytic reaction marked.	Broder's Types 1 and 2.		Broder's Types 3 and 4.	
	Basal cell reg.	Basal cell irreg.	Basal cell reg.	Basal cell irreg.
	6 (12.7%)	6 (12.7%)	0 (0%)	4 (8.5%)
Lymphocytic reaction not marked or absent.	10 (21.3%)	3 (6.3%)	4 (8.5%)	14 (29.9%)

FIG. 24.—Factors influencing type of neoplasm.

manifest. In other words, if this argument is correct, the variation of tumor types is controlled by the factor of nutrition (Figs. 27A and B).

I recognize that this is by no means the end of the story, that there are factors which must underlie nutrition—body defensive mechanisms, such as lymphocyte barriers and influences of tissue tension—but these possibilities open up fields beyond the scope of our present discussion.

Atypical Tumors.—As I have already indicated, there are certain tumors arising from buccal epithelium which cannot be included under the acanthomata group, and their variations are so great that it is impossible to include them under any single collective heading. I propose to do no more than mention the individual types which we have encountered.

(A) *Spindle-celled Epithelioma* (Fig. 28).—In this instance a warty tumor the size of a marble developed on the margin of the tongue. Microscopically, the tumor appeared to originate from the basement cells of the epithelium, but, instead of assuming the variations of the acanthoma group, the cells presented a most curious fusiform appearance, so much so that the pathologist who examined them raised the possibility of the tumor being a fibrosarcoma.

(B) *Mucoid Epithelioma.*—We have used this descriptive term because of the peculiar degree of mucoid degeneration in the tumor stroma. The clinical characters

CARCINOMA OF MOUTH AND TONGUE



FIG. 27A.—Macroscopical types Ulcerative.



FIG. 27B.—Papilliferous.



FIG. 28.—Spindle-cell epithelioma.

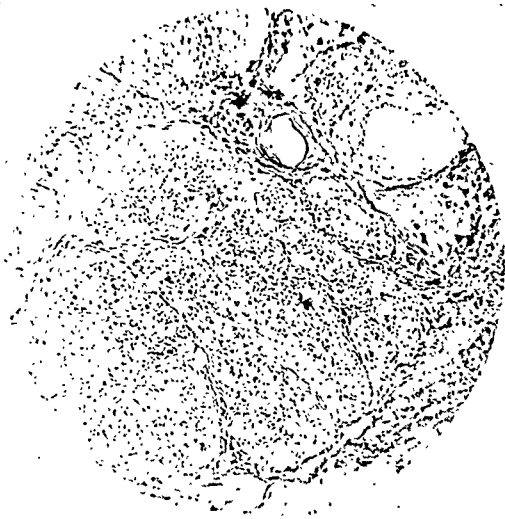


FIG. 29.—Mucoid epithelioma.

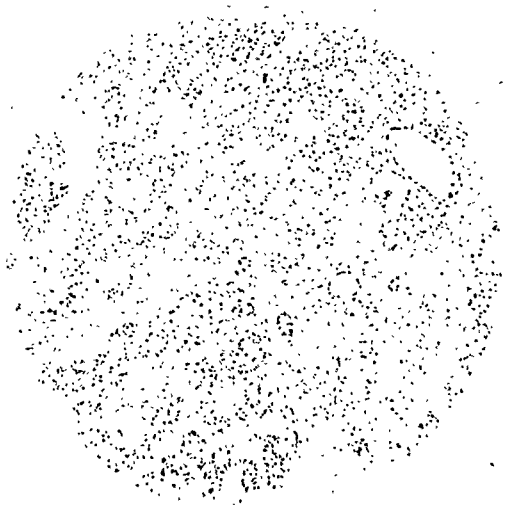


FIG. 30.—Alveolar epithelioma of floor of mouth.



FIG. 31.—Adenanthinoma of alveolar margin.

were those of a small nodule at the tip of the tongue showing surface ulceration (Fig. 29). The tumor was composed of cells showing the characters of basal cells, the invasion was by means of migration into the sub-epithelial area, but the distinctive feature was the remarkable degree of mucoid degeneration in the surrounding stroma.

(C) *Alveolar Epithelioma*.—In this instance the clinical features were those of a non-ulcerated tumor of the gingio-lingual sulcus immediately lateral to the frenum (Fig. 30). The histopathology was that of a basal-celled epithelioma in which the cells assumed a peculiar acinar-like arrangement. The structure was not unlike the appearance of salivary tissue in an early stage of development, and the suggestion is that the tumor may have originated from a portion of epithelium designed to form salivary or sub-mucous gland tissue.

(D) *Adamantino-epithelioma*.—A tumor originating from the alveolar margin (Fig. 31) of the lower jaw in contiguity with a tooth was found to present the appearance of solid masses of cells showing in the centre a reticular change similar to that in the nucleus of a developing tooth, and it is suggested that in this case a basal-celled tumor originated in that portion of the epithelium which was concerned with the development of the tooth germ.

(E) *Mixed Tumor of Salivary Gland Origin*.—A slowly growing tumor of six years' duration originating from the right tonsil and presenting a smooth non-ulcerating surface was found on microscopical examination to show characters of a complex type similar to those of a mixed tumor of salivary gland origin (Fig. 32). Squamous epithelium, acinar epithelium, and myxomatous tissue were present.

(F) *Endothelioma*.—A small ulcerating tumor of the hard palate (Fig. 33) was revealed as an endothelioma.

(G) *Melanoma*.—In two instances an ulcerating and pigmented tumor of the hard palate showed the typical appearance of a melanoma (Fig. 34).

(H) *Lympho-epithelioma*.—A bulky, rapidly growing tumor of the right tonsil (Fig. 35) was found to consist of basal cells combined with numbers of large cells of the lymphocyte type. The microscopical characters of the tumor were similar to those described by Regaud under the title of lympho-epithelioma.

(I) *Tumors of the Transitional Cell Type*.—In three instances tumors originating apparently from buccal epithelium assumed the characters of the transitional type (Fig. 36) as encountered in tumors of the urinary tract, the cells being arranged along strands of vascular connective tissue.

I have alluded to these various atypical tumors in order to remind ourselves that, while the acanthoma group is that which is most truly representative of buccal epithelium pathology, a variety of atypical types may present themselves.

The Methods of Spread.—The original tumor formation extends by certain recognized modes and channels—by local invasion, particularly along fascial planes, by lymphatic spread (Fig. 37), by blood spread, and by a method which is really a variety of lymphatic spread, infiltration along the perineural spaces. The method of local invasion is that common to carcinomata in any situation; the lymphatic spread is usually in the perivascular and perineural lymphatics. In the immediate proximity of the tumor the mode of spread is by permeation, but this method appears to cease in the environs of the tumor, and thereafter it appears to be by a vehicular or embolic spread (Fig. 38). The blood dissemination of an epitheliomatous tumor is recognized as an unusual event. In three instances we have been

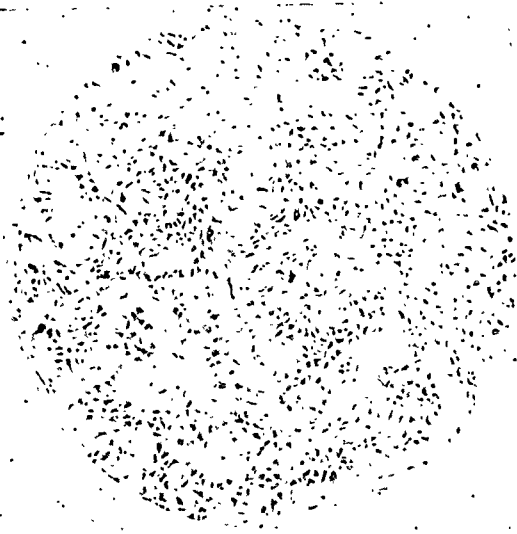


Fig. 32.—Mixed tumor of palato-glossal area.

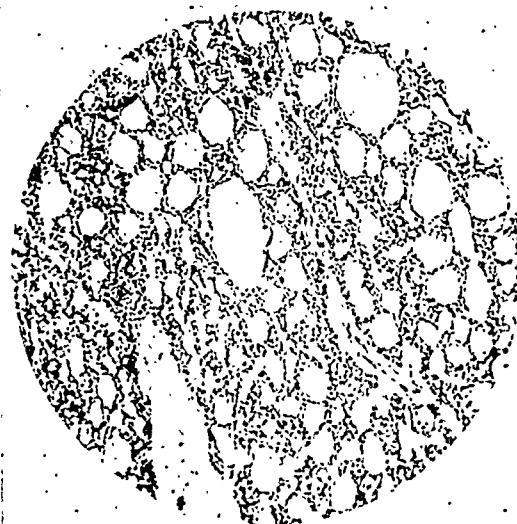


Fig. 33.—Endothelioma of palate.



Fig. 34.—Melanoma of palate.

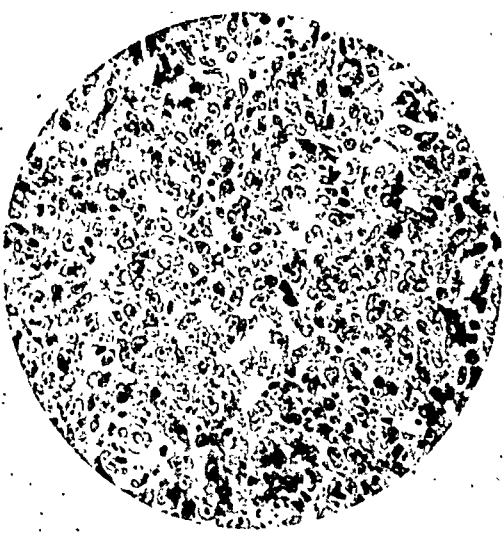


Fig. 35.—Lympho-epithelioma of tonsil.

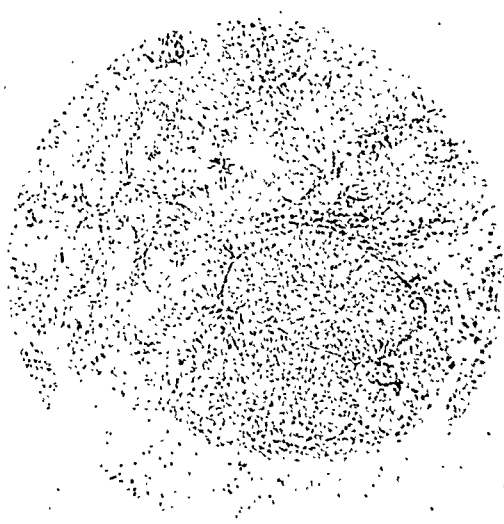


Fig. 36.—Transitional type of epitheliomata.



Fig. 37.—Lymphatic spread of tumor.

able to demonstrate invasion of a blood-vessel by a malignant infiltration, so that a carcinomatous plug occupied the vessel lumen (Fig. 39). In each instance the original tumor was of a peculiarly vascular type. (Group IV.) Blood dissemination, however, is not a serious risk, because it would seem that the epithelial malignant cell is unable to exist for any length of time in the blood-stream (Fig. 40). It is this fact which explains the rarity of visceral metastasis as a sequel to buccal carcinoma. As regards perineural spread, referred nerve pain is one of the most distressing features of an established buccal carcinoma. It may be that the explanation is afforded by this phase of the pathology, for the observer is at once impressed by the frequency with which a perineural spread is observed (Fig. 41). No doubt the perineural lymphatics are the actual channels of the conveyance, but the contact with the nerve elements is very close and in several instances the nerve bundles have been infiltrated (Fig. 42). It is at once evident that such a condition must be associated with nerve pain, but whether it can be accepted as a constant explanatory factor is doubtful (Fig. 43).

The Problem of Treatment.—However deep may be our interest in questions of etiology and pathology, we recognize that as practical surgeons it is the problem of treatment which most intimately concerns us. The subject is a difficult and in some respects a distressing one, for we cannot be blind to the fact that, except in certain chosen and early cases, the results obtained give us cause for anxiety. We have analyzed our records in respect of treatment, as they are presented over a period of ten years, and I think some interest attaches to them, as they concern a variety of methods and afford therefore a basis for comparison.

The general term "surgical treatment" may cover any of the well-accepted methods.

(1) Excision of the tumor by scalpel or diathermy, together with a radical dissection of the related lymphatic field.

(2) Radium or X-ray treatment of the local area, combined with radical dissection of the lymphatic field.

(3) Radium or X-ray treatment of both the local and the lymphatic areas.

We have had an opportunity in a modest way of evaluating the results of certain of these procedures, and, though I recognize that our figures are too few to be of real value from a statistical point of view, I propose to present them to you.

(1) *The Operation of Radical Excision.*—Until the advent of radium therapy this, of course, was the method universally employed. The procedure was and still is in certain cases to remove the affected area by a wide excision, using the scalpel in the majority of cases, diathermy in a minority. A radical dissection of the related gland groups is an obvious corollary to the central operation, and it is apparent that this stage of the procedure may

CARCINOMA OF MOUTH AND TONGUE

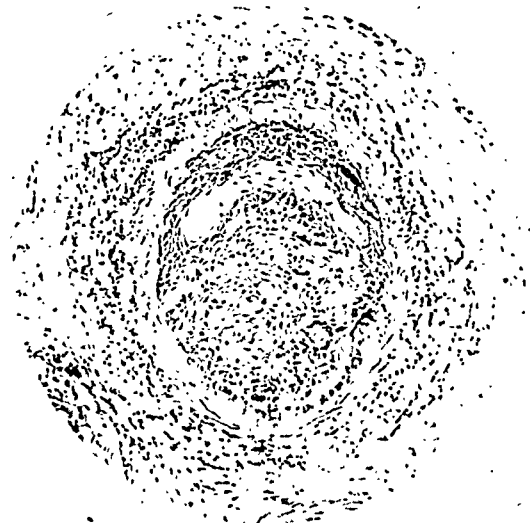


Fig. 38.—Lymphatic spread of tumor, with commencing cell-nest formation.

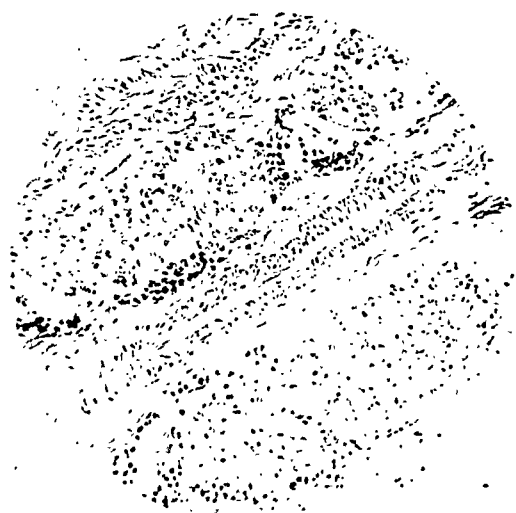


Fig. 39.—Invasion of perivascular lymphatics.

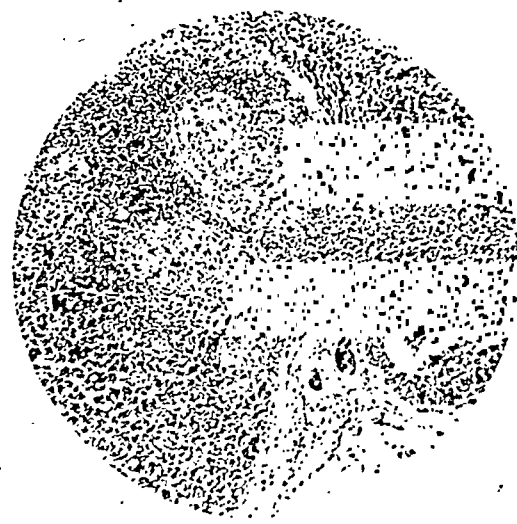


Fig. 40.—Malignant embolus arrested in capillary lymphatic with endothelial reaction.

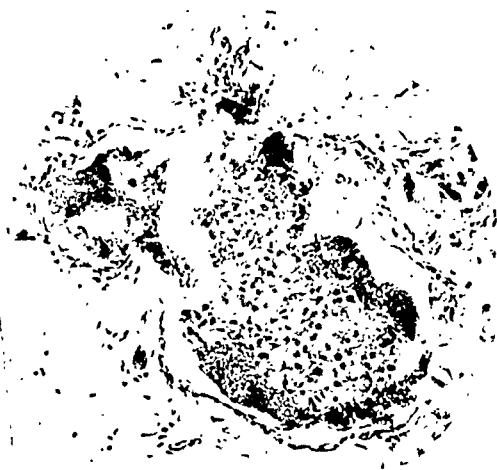


Fig. 41.—Blood spread of carcinoma. Malignant cells free in blood-stream.



Fig. 42.—Commencing infiltration of nerve by malignant cells.



Fig. 43.—Neural invasion.

be coincident with, may precede, or may follow the excision of the mouth lesion. The gland dissection was made as complete as possible on one or other of the well-recognized block plans. A total of sixty-eight cases has been treated on these lines. They form the earliest group of the total series, and in estimating the results it is well to point out that the most recent case in the series was operated on two and one-half years ago, and that a period of ten years prior to that time is included.

I must allude to one further point before submitting the analysis. It is this—that, in order to get an accurate idea of the prognosis, we must divide the cases into two major groups: (*a*) those in which no glandular involvement was evident, on clinical or microscopical examination (forty-two cases) and (*b*) those which showed glandular involvement at the time of operation (twenty-six cases). With these somewhat numerous provisions let us now witness the results.

Looking at the question as a whole, the analysis of the sixty-eight cases is shown in the following table:

TABLE I

<i>Total</i>	<i>Cured</i>	<i>Recurred</i>	<i>Died</i>	<i>Untraced</i>
68	16	31	20	1
	(23.5%)	(45.5%)	(29.4%)	

I have tried to be reasonable and careful in the use of the all-important word "cured," and as far as is possible undue optimism has been guarded against, for the most recent case included in this group was operated on two years ago, and I think you will agree that where carcinoma of the mouth is concerned, that is a moderately good prognosis index. I need scarcely add that many of the cases are alive over a longer period of time. The death rate has been estimated as including those cases in which death might be ascribed to the operation or its immediate effects.

The results indicate that there is a proportion of cures amounting to 23.5 per cent., with a mortality rate of 29.4 per cent. as estimated over the total series of sixty-eight cases.

Let us go farther and reproduce a somewhat similar table, taking cognizance of the major distinction I have indicated, the presence or absence of glandular involvement. On this basis the results are as follow.

TABLE II

	<i>Total</i>	<i>Cured</i>	<i>Recurred</i>	<i>Died</i>	<i>Untraced</i>
Group A (No glandular involvement)	42	15 (35.7%)	17 (40.5%)	9 (21%)	1
Group B (Glands in- volved)	26	1 (3.8%)	14 (53.8%)	11 (42.3%)	

The table brings out the well-recognized truth that glandular metastasis is the touchstone by which the prognosis must be eventually judged.

CARCINOMA OF MOUTH AND TONGUE

So much for the general conception. Let us now look at another aspect of the question, but it may be that it conveys a lesson of practical significance. I have said that the incidence of the gland portion of the operation may be simultaneous or preceding or subsequent. I must add that in a certain number of cases no gland excision was attempted, usually because the patient was unwilling to face the ordeal. This group is included in the following summary. Analyzed on this basis the results are as follow :

TABLE III

<i>Method</i>	<i>Total</i>	<i>Cured</i>	<i>Recurred</i>	<i>Died</i>	<i>Untraced</i>
Local excision	25	5 (20%)	11 (44%)	8 (32%)	1
Simultaneous local and glands	19	5 (26.3%)	4 (21%)	10 (52.6%)	
Local operation first glands later	9	3 (33.3%)	6 (66.6%)		
Gland operation first local later	15	3 (33.3%)	10 (66.6%)	2 (13.3%)	

The lesson which this table would seem to convey is that, if we are to secure the lowest mortality rate, the operative procedure should be in two stages, the glandular dissection being either before or subsequent to the tumor excision. In twenty-four cases so treated the mortality figure was 8.3 per cent., while in the simultaneous group the death rate reached the deplorable figure of 52.6 per cent.

There still remains for discussion the much debated problem as to whether, if the operative procedure is to be in two stages, the tumor excision should precede the gland dissection or *vice versa*. On pathological grounds the former is probably more correct, because if we proceed to remove the glandular area while the local error remains *in situ*, a phase is apt to ensue in which cancer cells will continue to migrate by the lymphatics and thence through the cut surfaces into the tissue planes of the neck. I expect that some of us have had the disconcerting experience of witnessing the malignant cellular infiltration which is apt to follow the gland precedence two-stage operation. I cannot leave this aspect of the subject, however, without reporting what many writers have described, that from the psychological point of view the suffering and distress of a preliminary mouth operation are such that the patient resolutely refuses any further operative interference. This was the factor which led to the existence in our own series of a group of cases in which we had to be satisfied with local excision of the tumor area. There is, however, another side to the question. If we are to judge the operative procedure from the standpoint of recurrence, the smallest recurrence incidence is encountered in the one-stage or combined operation.

In discussing the results of excision methods of treatment it may seem as though I am recounting what is ancient history, and I daresay there are some who may suggest that the very mention of such mutilating procedures

is uncalled for in these days of radiotherapy, but my intention is to speak in terms of comparison and after all is said and done we live in changeable days, the pendulum may even yet swing back, and in any event for some time to come there will be cases in which the best chances of complete recovery will lie along the lines of a radical surgery.

(2) *Radium Treatment*.—This, the last section of my paper, I present with a certain measure of diffidence, for our experience has not been large, but as an experience with an individual group of cases—an experience in which we have experimented, so to speak, with the matters of dosage and method of application—the record may be of interest. For purposes of description I propose to divide the record into three epochs, early, middle, and present.

The Early Period.—When we first began using radium in the treatment of mouth carcinoma we were, I think, rather fearful of its results, apprehensive of its power as a tissue destruction agent, and relatively untutored in the technic of its application. Affected by influences such as these, we used small doses applied by the interstitial method in the form of 0.5 milligram needles, the total dosage varying from twenty to thirty milligram hours per cubic centimetre of tumor tissue. The results obtained as far as the local lesion was concerned in a series of cases were as follow :

TABLE IV

Small Dosage Group (20 to 30 mgm. hours per c.cm. of Tumor Tissue)
Interstitial Method (10 Cases)

Local lesion healed	10%
Temporary healing followed by recurrence	40%
Local lesion unchanged	20%
Local lesion aggravated	30%

These, of course, were unsatisfactory results, and consideration showed that two points were probably at fault—an insufficiency of dosage and (less definitely, perhaps) an error in the technic of administration. From this point, therefore, we entered what may be termed the middle phase of our progress, and there followed a group of cases in which a heavy radium dosage was employed (200 to 300 milligram hours per cubic centimetre of tumor tissue), while the method of application was a Stent surface applicator. Our results were certainly improved, but difficulties were encountered. There was the problem of so arranging the Stent plate that a continuous and reasonably comfortable application was secured. In this difficulty we had the assistance of an extremely ingenious dental surgeon, Doctor Robertson, who by his ingenuity overcame what seemed insuperable difficulties, but in certain situations even he had to own defeat. More disconcerting still was the degree of sloughing which followed the application of the heavy dosage. In the soft parts healing usually ensued, but in several cases the necrosis involved the bones of the jaws with disconcerting results. I submit a table which indicates the results as far as the mouth lesion was concerned :

CARCINOMA OF MOUTH AND TONGUE

TABLE V

Results of Treatment of Local Lesion

Surface Radiation and Heavy Dosage (200-300 mgm. hours per c.cm. of Tumor Tissue
(15 Cases)

Local lesion ultimately healed, often considerable local sloughing.....	86.0%
Necrosis of bone leading ultimately to fatal result.....	6.6%
Local recurrence following temporary improvement.....	8.6%

Our *present phase* is one of a moderate dosage (and by that I mean an amount of 100 to 150 milligram hours per cubic centimetre of tumor tissue) applied where possible by a surface application, or, if this should prove unsuitable, by the interstitial method.

We are satisfied that we have obtained our best results where the local lesion is concerned by the method of surface application. We are unwilling to introduce needles into the tissue because we believe that in certain instances this procedure permits the entrance of infection into the surrounding tissue, and thereby stimulates cell division and tumor progress. A moderate surface dosage, with the minimum of damage and destruction to the part, appears to offer the best prospects of a satisfactory result.

There is considerable variation in the way in which tumors respond to radium therapy. Broders recognized this peculiarity in his classification, and he has alluded to the fact that the undifferentiated type (Group IV), is that which shows the quickest response to radio-active substances. I believe it will ultimately be found that the degree of cell resistance is in relation to the amount of keratin which the cell contains, that full keratinization, with its associated cell next formation, is a phase of cell change which is peculiarly resistant to radiotherapy.

The Problem of the Glands.—The problem of the cervical glands is a difficult one. The efficacy of radium in this situation is open to serious question, and for myself I feel that the most satisfactory way of dealing with the lymphatic field is to submit it to a radical block dissection elimination. If there is already such glandular invasion that radical removal is out of the question, we must be satisfied with the method of interstitial radiation, using a large dosage.

General Procedure.—I conclude with an outline of the procedure we at present adopt in an early case of buccal carcinoma. The preliminary treatment implies the correction of all areas of infection within the mouth; all the teeth are removed except such as may be required for the fixation of the dental plates, the gums are painted night and morning with equal parts of tincture of iodine and tincture of aconite, and appropriate mouth-washes are used. At this time a suitable dental plate is made by the dentist. When the interior of the mouth is sufficiently clean, the radium carrying plate is applied, it being so arranged that the tumor area and a surrounding segment of half an inch are submitted to the influence of the radium; by means of a lead, or preferably a platinum, screen the healthy portions of the mouth are protected from the influence of the Beta rays. The plate is kept *in situ* until

a sufficient dosage has been secured; it should be removed for meals or other special purposes, but a careful note should be kept of the time period which such removal may imply. As I have already said, if the difficulties of surface application should prove insuperable, we employ the method of interstitial radiation.

When the surface lesion is healed the glandular tissue on the affected side is dissected. I believe it is inadvisable to do the glandular operation before the mouth lesion is corrected, the reason being that if we carry out the neck dissection while the primary focus exists, we are submitting the patient to the risk of a malignant infection of the cellular tissues of the neck along the lines of the cut lymphatics. It is probably particularly dangerous to practise a glandular dissection during the early stages of radium application to the local lesion, for at this time malignant cells are passing from the periphery of the tumor to the related lymphatics. In the course of the glandular dissection we introduce thirty to forty milligrams of radium underneath the posterior portion of the digastric muscle, this being an area in which the most thorough dissection is liable to be incomplete, and the insertion of the radium constitutes a greater degree of security. Ten days after the first glandular dissection the tissues of the opposite side are removed.

In a small proportion of cases the technic concludes with the application, after all wounds are healed, of a Columbia paste of Stent collar carrying a large surface dosage of radium. I confess I am doubtful about the efficacy of this last procedure, but we have occasionally employed it.

Thereafter the patient reports at monthly intervals for a period of six months, and then at intervals of three months until two years have elapsed.

I recognize that my remarks regarding radium therapy are indefinite but I have attempted to present the procedure which we adopt. I have not alluded to end-results because insufficient time has elapsed to justify any opinion.

We feel that there is probably no fixed and uniform carcinoma dose—that if the tumor is to be affected a certain minimum radiation is necessary but on the other hand a maximum dose must not be exceeded or if we are to avoid injury to the normal tissues.

In conclusion, I want to say how much I owe in the preparation of this paper to my clinical assistant, Mr. Eric Mekie—the bulk of the pathological work has been done by him. I also very gratefully acknowledge the great amount of technical assistance I have had from Mr. Smith and his assistants in the Department of Clinical Surgery.

THE PATHOGENESIS AND SYMPTOMS OF CHRONIC OBLITERATIVE APPENDICITIS

BY J. SHELTON HORSLEY, M.D.

OF RICHMOND, VA.,

AND

HARRY J. WARTHEN, JR., M.D., BY INVITATION

OF BALTIMORE, MD.

CHRONIC appendicitis is usually divided into three classes—catarrhal, interstitial, and obliterative. As to the first two classes, the catarrhal and the interstitial, there are a variety of opinions, some even doubting their existence. We will not discuss them, but concern ourselves with obliterative appendicitis.

Since the early days of appendicitis, various writers have commented upon that type in which the lumen of a portion or all of the appendix has been slowly obliterated. This kind of appendicitis has been called by various names, such as "appendicitis granulosa," "fibroid degeneration of the appendix," "appendicitis irritans," "protective appendicitis," and "chronic obliterative appendicitis." There were different explanations of this condition. Some, as W. J. Mayo, Robert T. Morris, Ribbert, and others, placed chronic obliterative appendicitis as an involutionary and physiological phenomenon. Others, as Senn, Fitz, and MacCarty, thought it was inflammatory, beginning in the mucous membrane as a superficial ulceration, in the deeper layers as an interstitial process, or as a lymphatic infection.

It is not our purpose to quote fully the literature on this subject, which is quite voluminous and which can be readily consulted. However, some of the opinions must be presented to indicate the status of this disease.

MacCarty and McGrath pointed out that the process of obliteration of the lumen of the appendix occurs during all ages, from five years to old age, and that its activity is greatest between birth and forty years of age. The average age at which the lumen is found to be completely obliterated is 34.6 years for appendices removed for appendicitis, and 39.1 years for appendices removed during operation for cholecystitis. They state that the tip may be obliterated at five years of age, and the total lumen at ten years of age. Either complete or partial obliteration of the lumen was found to occur in 23.5 per cent. of 1,005 specimens removed for appendicitis alone, and 22.8 per cent. of 5,000 specimens removed for appendicitis associated with other abdominal conditions. The oldest patient with total obliteration was sixty-nine years of age, and the youngest ten.

MacCarty calls attention to the occurrence in obliterative appendicitis of carcinoma of the appendix, which apparently is due to a chronic inflammatory process. He states that 90 per cent. of carcinomas of the appendix are found in partially or completely obliterative appendicitis.

According to Pfeiffer, obliteration of the lumen of the appendix occurs as a result of certain types of acute appendicitis in which the mucosa has become completely gangrenous, without gangrene of the outer coats. Such conditions, however, must be rare unless accompanied by acute symptoms. It is difficult to imagine complete gangrene of the lining of the appendix without sufficient surrounding reaction to cause very

marked symptoms, even though the peritoneal coat may not be actually involved in the gangrenous process; though histories of previous severe attacks of colic or abdominal pain are sometimes so indefinite that the possibility of such an occasional occurrence cannot be denied.

Eli Moschcowitz maintains that there is no pathological evidence of involution of the appendix or catarrhal inflammation of the appendix. Chronic appendicitis, according to Moschcowitz, usually represents the healed result of an acute lesion.

According to Ribbert, the first signs of obliteration may occur in the fifth year of life, while in more than 50 per cent. of patients over sixty years of age some stage of obliterative appendicitis is seen.

Hugh Cabot speaks of chronic appendicitis as the scapegoat of abdominal surgery. He says we must not forget the fact that appendices are larger in children and smaller in old age, relatively speaking. In old age there is some process going on which shrinks the organs.

This change that Cabot mentions, however, is not confined to the appendix; the liver, for instance, is relatively much larger in the new-born infant than in an adult, and the thymus almost disappears after adolescence, while the prostate tends to enlarge in the old.

P. Masson, of Lyons, France, says that when an inflamed appendix becomes blocked, the nerve terminals may proliferate and form an actual neuroma. Masson has seen neuromas of the sympathetic fibres enclosed in a sheath and this in a shell of muscle. The contraction of the muscular shell may set up reflex action as with a neuroma after an amputation and give symptoms. This neuroma formation was found in all but one of his ten cases of obliterative latent appendicitis.

To show the status of the opinion about obliterative appendicitis, Royster, in his monograph on appendicitis, says: "In the midst of these varying views, it might be safe to conclude that obliteration of the appendix may result from a chronic pathological process, or from a physiological atrophy. Whether any clinical differences between these two types are distinguishable is difficult to determine."

The advocates of the theory of physiological involution as the explanation of obliterative appendicitis say that this condition is found more often in elderly people than in the young, and that it usually gives few, if any, symptoms. Histological examination may show complete obliteration of the lumen, but occasionally there is a thin growth of a superficial epithelium along the almost completely obliterated lumen. This, it is argued, is an evidence of a physiological process, otherwise the epithelium would have disappeared completely. This epithelium, however, is not often found, and, when present, would seem merely to indicate that epithelium may spread over a healing surface. The epithelialization of a raw surface is a common phenomenon. We have noticed that even in experimental reconstruction of the common bile-duct in a dog with a transplanted section of a vein there is a tendency for the epithelium of the bile-duct to grow over the venous transplant.

The fact that obliterative appendicitis is found more frequently in the old than in the young is not proof that this condition is physiological and involuntary. A worn bearing in an automobile is more common in old cars than in new. The longer a biological machine, such as the human body, exists, the more probability there is of its organs becoming in some way affected. It has been said by Osler and others that in a large majority of necropsies of those dying past forty years of age, evidences of healed or arrested tuberculosis are

found. The argument, therefore, might be equally well sustained that tuberculosis is a disease of old age.

The specimens which we have examined have shown a range from slight obliteration at the tip of the appendix, the rest of the appendix being almost normal, to obliteration of its entire lumen. There are almost all stages between these two extremes, and in more than half (58.7 per cent.) of those without complete obliteration some evidence of inflammation is found on the proximal side of the obliteration. This seems to indicate that the process of obliterative appendicitis usually begins in the tip of the appendix as an inflammation and may be limited to this region, or, if the inflammation continues, may gradually proceed toward the base. The inflammation that produces this lesion is comparatively mild. It is well known that certain types of inflammation predispose toward cicatricial contraction more than others. Hepatitis, for instance, may result in cirrhosis in which almost all of the parenchyma of the liver is strangled by the contracting scar tissue; but all types of hepatitis do not lead to cirrhosis. Some of them produce abscesses; some, marked parenchymatous degeneration; while others appear to subside, leaving no trace. This inflammation of chronic obliterative appendicitis chiefly affects the mucous membrane, and usually begins at the tip of the appendix, probably because it forms a cul-de-sac, and with the stagnant fæces acts as an incubator.

Upon the process of chronic obliteration a typical acute appendicitis may be imposed. We have not infrequently seen an acute appendicitis with violent inflammation added onto an obliterative process.

The absence of symptoms or the comparatively mild clinical signs and symptoms induced by obliterative appendicitis are considered an argument for the involutionary process. The chief cause of pain in appendicitis appears to be pressure, doubtless along with a sensitizing of the nerves from the congestion and infection. But in chronic obliterative appendicitis none of these conditions is conspicuously present. Certainly the inflammation is accompanied by very little hyperæmia, and there is no acute pressure. As the ulcerative process slowly proceeds toward the base of the appendix it leaves a healing mass of tissue and scars in its wake. There is no obstruction to appendicular drainage, and there is no occasion for unusual pressure. This process involved in chronic obliterative appendicitis may, rarely, begin in some other regions of the appendix, as in the base or in the middle. When a stricture occludes the lumen of the appendix and leaves the distal portion unobliterated, symptoms may arise quickly. If there is infection, the lack of drainage from the appendix may cause a typical acute appendicitis. If there is but little infection, the products from the mucous membrane cannot be drained into the cæcum by the natural route, and there may be a gradual accumulation of mucus, causing cystic dilatation.

Strictures of the appendix doubtless have several etiological factors, the most common being a local acute or subacute inflammatory lesion, but it seems logical to expect that the process of obliterative contraction of the lumen usually beginning at the tip may occur at other parts of the appendix. We

have observed a case (Figs. 1 and 2) in which this obliterative process began at the base of the appendix instead of at the tip. (Mrs. J. P. T., Case No. A1828.)

The obliterative appendicitis found in the aged has probably existed for years. It has been definitely shown that chronic obliterative appendicitis may be present in a patient five years of age. In one of our patients, seventeen years of age, the lumen of the appendix was completely obliterated. It is not an involution process or a respecter of age as, for instance, wrinkling of the skin, atrophy of the uterus, or other changes common to increasing age or to lack of function. In the young the lymphatics are abundant and the tissues juicy. Cancers in the young are usually rapidly growing and not often of



FIG. 1.



FIG. 2.

FIGS. 1 and 2.—Mrs. J. P. T. (A1828), aged forty-five years. Operation October 10, 1929. The appendix was five and one-half centimetres long. The distal three-fourths were about normal size. The proximal fourth was sharply contracted, with the area of contraction beginning at the base. The lumen was greatly contracted in the proximal fourth and had almost disappeared. The lumen of the rest of the appendix was larger, but was somewhat smaller than normal. There was some congestion of the mucosa, particularly in the distal portion. This represents obliterative appendicitis near the base.

the scirrhus type. The more highly classed tissues, such as the epithelial tissues, are more likely to survive and to repair under the conditions of youth with excellent lymph circulation and blood supply than in old age. It seems probable, then, that infection in the young would be more rampant and less likely to go the more conservative methods of slow inflammation than in the aged.

Hellwig, in writing upon obliteration of the vermiform appendix, says: "An appendix with complete obliteration will not undergo inflammation again and its removal will not relieve the patient of his symptoms. An appendix with partial obliteration, on the contrary, is disposed to recurrent inflammation, because the stenosis of the non-occluded portion and the fibrosis of the muscle layers favor retention of its contents and bacterial invasion of the mucosa."

CHRONIC OBLITERATIVE APPENDICITIS

The statement of Hellwig, which appears to represent the opinion of many surgeons, that the removal of an appendix with a completely obliterated lumen will not relieve the patient of his symptoms, is contrary to our clinical experience. It must be recalled that the same lesion in different individuals will often produce different symptoms. A neuroma in one patient may be exquisitely sensitive, while a neuroma of a similar histological type in another may give no symptoms or very slight discomfort. This should not mean that, because one person with a neuroma complains little or none at all, the one who does suffer should go unrelieved.

A study of 273 cases of appendicitis with the lumen of the appendix partially or completely obliterated which have been operated upon at St. Eliza-

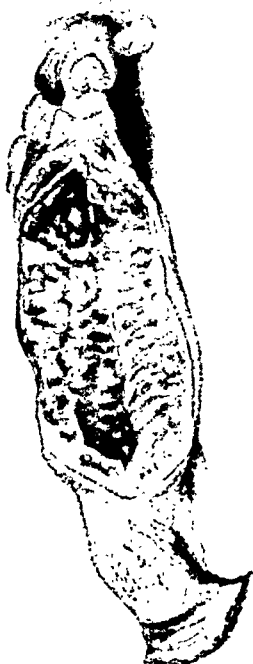


FIG. 3.



FIG. 4.

FIG. 3.—Mrs. N. L. (7678), aged thirty-two years. Operation March 28, 1923. The appendix was seven and one-half centimetres long, deeply congested. The tip was nodular, firm and white. The mucosa was deeply congested throughout and in small patches showed necrosis. The obliterated portion at the end was about one centimetre in length. The wall was thick, and the lumen had almost disappeared. There was apparently no mucosa. The patient had marked acute appendicitis.

FIG. 4.—Mrs. R. (A39), aged thirty-five years. Operation October 31, 1925. The appendix was six and one-half centimetres long, thickened at the tip and near the tip the lumen was almost obliterated. Adjoining this the mucosa showed an ulcer which extended well through the superficial portion of the mucosa. Elsewhere the mucosa was apparently normal.

beth's Hospital, Richmond, Virginia, from January 1, 1922, to January 1, 1932, gives interesting information on some of these mooted points. During that decade there were removed at this hospital 1,713 appendices.* The

* Two cases of cancer of the appendix, 368 cases of subacute appendicitis, 56 cases of acute appendicitis with spreading or general peritonitis, 55 cases of acute appendicitis with perforation, 35 cases of acute appendicitis with abscess, 534 cases of acute appendicitis, and 663 cases of chronic appendicitis or normal appendices many of which were removed incidentally during operations for other conditions.

proportion of partially or completely obliterative appendicitis to all the appendices removed is 15.39 per cent.

The specimens reveal many stages, from beginning obliteration at the tip (Figs. 3 and 4) to a complete obliterative appendicitis, the appendix being converted into a small cord without any lumen, or with merely a trace of brownish tissue around a minute lumen. Cases with mere thickening at the extreme tip of the appendix, without some closure of the calibre of the appendix near the tip, are not classed as obliterative appendicitis, as this condition may result from a congenital thickening or from an acute local inflammation that does not tend to extend. However, it would be difficult to differentiate some of these cases from early obliterative appendicitis. In eighty-nine cases there was complete obliteration



FIG 5



FIG 6.

FIG 5—Miss F. W. (A166), aged thirty four years. Operation December 18, 1925. The appendix was eleven and one half centimetres long. For about two centimetres at the tip the appendix was smaller than elsewhere, was firm and hard, and the lumen had entirely disappeared. There was a superficial ulcer on the proximal side of this area. This was definitely marked off for about one centimetre. The tip was firm and the mucosa had entirely disappeared. Between this region and the ulcer, for about one and one half centimetres, the mucosa was atrophied. The wall was very thick. It appeared to be undergoing the process of obliteration with the very distal mucosa completely obliterated, the adjoining mucosa almost destroyed, and next to this an ulcerated area of otherwise normal mucosa.

FIG 6—Mrs M. J. C. (9529), aged thirty five years. Operation May 8, 1925. The appendix was six and one half centimetres long. At the tip was a thickened area in which the mucosa had disappeared for a distance of about one half centimetre. On the proximal side of this the mucosa was stippled and slightly congested and swollen. This extended to the junction of the distal and middle thirds.

of the lumen. Subtracting this from the total number of cases of obliterative appendicitis leaves 184 with incomplete obliteration. There was noted either superficial ulceration or hyperæmia confined to the mucosa adjoining the obliterative portion of the appendix or most evident in this region in sixty-one of these 184 cases (Figs. 4, 5, 6 and 7), and erosions or hyperæmia diffusely placed throughout the mucosa as well as near the obliterative portion in forty-seven cases. In seventy-six cases no signs of hyperæmia

CHRONIC OBLITERATIVE APPENDICITIS

or ulceration in the mucosa were observed at the time of operation. This does not necessarily mean, however, that this process had not been present at some previous time. With such a large proportion (108 out of 184 cases, 58.7 per cent.) showing



FIG. 7.—Mr. O. E. L. (A2489), aged forty-two years. Operation, February 3, 1928. The appendix was eight centimetres long. The distal end for about one and one-half centimetres was entirely occluded. The mucosa adjoining this was eroded, more marked at the junction with the occluded portion. The mucosa in the proximal portion was apparently normal. Photomicrographs of this specimen will be shown.

evidences of superficial ulceration and inflammation adjoining the obliterated portion and with only that portion of the mucosa next to the obliterated portion involved in sixty-one cases, it seems probable that this inflammatory process had existed at some time in all of these 184 cases but in those in which it was not obviously present at the time of operation the process was in abeyance. We know that acute inflam-

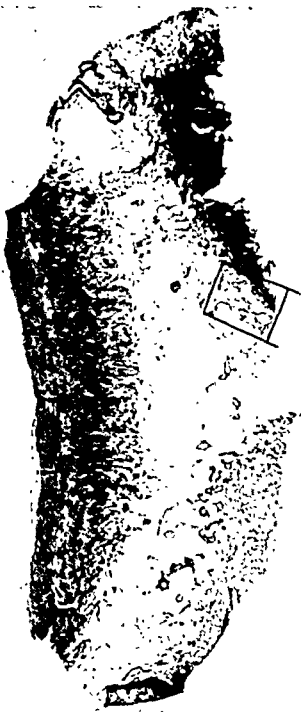


FIG. 8.

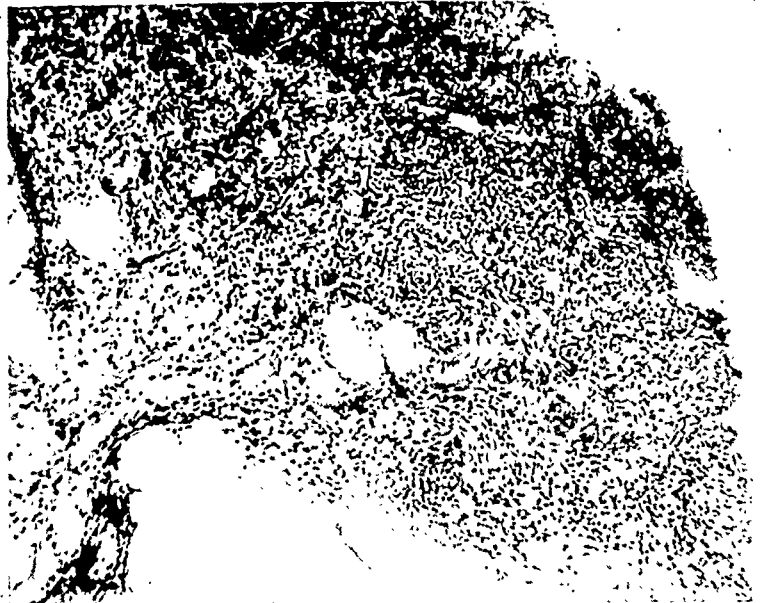


FIG. 9.

FIG. 8.—Longitudinal section of appendix shown in Fig. 7, ($\times 10$), showing area of congested mucosa at the line of demarcation with the obliterated portion.

FIG. 9.—Blocked-out area of the preceding figure ($\times 100$). To the left and above is the infiltrated area containing some remnants of mucosa and much leucocytic infiltration, gradually blending into the obliterated portion to the right and below.

mation of the appendix, of the gall-bladder and of other organs or tissues may pass off and leave but little if any trace of the attack.

All of these appendices have not been studied histologically, but a histological study of some of them is interesting. A cross-section of the oblitative portion pre-

sents a fairly uniform picture. The muscular coat is usually well preserved. In the lumen there is a mass of irregular tissue, much of which seems reticulated containing some fat and showing ordinary connective or scar tissue, but no epithelium. In all of the specimens histologically examined there is evidence in the obliterative portion of old inflammation, such as young fibroblasts or leucocytic infiltration. A section including the junction of the obliterated lumen with the proximal appendicular mucosa which is inflamed shows a rather sudden transition into acutely inflammatory tissue, as shown by marked leucocytic infiltration, and some destruction of the epithelial cells. This usually gradually fades off farther toward the base into what may be considered normal appendicular tissue. Typical views of this process are shown in the photomicrographs, Figs. 7, 8, 9, 10, 11, 12, 13 and 14.

As for symptomatology, it is well known that the symptoms even of acute appendicitis may sometimes be puzzling, especially when the appendix is not



FIG. 10.



FIG. 11.

FIG. 10.—Cross-section of obliterated portion at the tip of the appendix shown in Fig. 7. ($\times 20$.) The mucosa had disappeared. The muscular coat was fairly well preserved. Most of the lumen had been filled with what appeared to be connective tissue with interstitial areas, probably occupied by fat.

FIG. 11.—Higher power of area blocked out in the preceding section. ($\times 100$.) Note the leucocytic infiltration of the tissue filling the cavity, and the comparatively normal muscular coat.

in its usual location. With obliterative appendicitis the type of pathology has much to do with the symptomatology. The great majority of appendices are located with the base under McBurney's point, and in obliterative appendicitis as in acute appendicitis the point of tenderness is usually over this point, but the tenderness from the appendix may be in the cul-de-sac or on the left side, or in the upper right hypochondriac region, depending upon its location.

In partial obliterative appendicitis, the symptoms cannot be necessarily attributed solely or even chiefly to the obliteration, because, as is well known, acute symptoms or even rupture may occur in the proximal portion of the

CHRONIC OBLITERATIVE APPENDICITIS

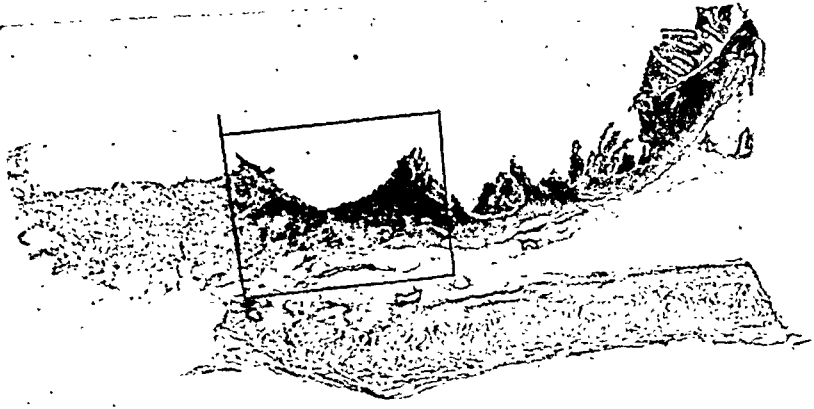


FIG. 12.

FIG. 12.—Dr. T. W. W. (A6232), aged thirty-seven years. Operation February 28, 1931. Appendix was ten and one-half centimetres long and obliterated throughout except for a small portion at the base. Section shows a small remaining mucosa near the base at its junction with the obliterated portion. (x 15.)

FIG. 13.—Enlarged area of the preceding figure that has been blocked out, showing leucocytic infiltration being more dense toward the base where normal mucosa existed. (x 60.)

FIG. 14.—Higher magnification of blocked-out area in preceding figure, showing marked leucocytic infiltration, decreasing toward the obliterated portion. (x 100.)



FIG. 13.



FIG. 14.

appendix when much of the distal part has been obliterated. Naturally, in such a case the symptoms are those of any other type of acute appendicitis, regardless of what has happened to the distal part of the appendix.

There are many individuals who have other pathological lesions in the abdomen that dominate those of obliterative appendicitis and there are others whose sensitive threshold is so high that a moderate amount of pathological lesions may create no symptoms.

There are in our series eighty-nine cases of complete obliterative appendicitis, but only in thirteen of these cases was an operation done solely for appendicitis with no other demonstrable pathological condition existing at the time except local adhesions in some of these cases. While this group is small, it was felt that following them up carefully would be indicative of the symptomatology of chronic obliterative appendicitis. The positions of these appendices, which were not identical in any two cases, may have had something to do with the difference in symptoms.

Of these thirteen patients with complete obliterative appendicitis, seven were men and six were women. All made a satisfactory operative recovery. The average age was thirty-five and one-half, the youngest seventeen and the oldest fifty-three years. The operations were done between October 14, 1923, and September 7, 1931. In eight cases the symptoms complained of before the appendix was removed were entirely relieved. In two cases the symptoms were not relieved, though one of these patients had hypertension and died six years later of apoplexy. In three cases the original symptoms were partially relieved but other symptoms appeared. All had pain on pressure over the region of the right iliac fossa, some at the lower portion and some at the upper, but most of them within two or three inches of the anterior-superior spine of the ilium. Most of the patients had suffered for months or years with recurrent attacks of abdominal pain, with "gas," "indigestion," constipation and a rather vague consciousness of abdominal discomfort. One patient (Mrs. J. B., No. 8172) had a typical attack of acute appendicitis and was operated upon as an emergency. She was completely relieved of her symptoms.

As this group is small, a brief abstract of each case is given.

CASE I.—Mr. R. N. C. (Case No. 8078), aged thirty-one years. Two years ago, six months ago, and for the past thirty hours the patient had pain in the right lower quadrant, with nausea and vomiting. There were no digestive disturbances between attacks. Appendectomy was done October 14, 1923. The appendix was 7.5 centimetres long, smaller than normal, slightly congested, with no adhesions. On section it seemed to be practically a solid cord to within a half-inch of the base where there was a small lumen. In this region the mucosa was atrophied and thin. The patient had hypertension. His symptoms were not entirely relieved by the operation. He died January 3, 1929, of apoplexy.

CASE II.—Mrs. W. L. A. (Case No. 8106), aged forty years. The patient had had indefinite pain in the abdomen, with constipation and "gas," for the past fifteen years. There was pain on pressure over the right lower quadrant of the abdomen. Appendectomy October 24, 1923, with division of Lane band. The appendix was 6.25 centimetres long, universally covered with adhesions, and had a short mesoappendix attached.

CHRONIC OBLITERATIVE APPENDICITIS

On section it seemed to have a completely obliterated lumen. Patient reported in April, 1932, complete relief from symptoms.

CASE III.—Mr. E. A. S. (Case No. A432), aged thirty-five years. The patient had tenderness and indefinite pain which was occasionally referred to the right groin and upper right thigh. The symptoms began eighteen months previously, with some tendency to constipation. For the past month there had been a dull pain in the right abdomen and the patient was always conscious of it. Physical examination showed slight rigidity of muscles of the right lower quadrant, and very slight tenderness on deep pressure. Appendectomy, April 3, 1926. The appendix was densely adherent, eleven centimetres long, and smaller than normal. (Fig. 15.) At the tip the appendix had narrowed down to a filament. This was removed without the peritoneal covering. This filament gradually merged into the large portion of the appendix which even then was not of normal size. The base was somewhat funnel-shaped and consisted of the appendix and the immediately adjacent cæcum. On section the lumen seemed to be entirely obliterated up to a centimetre of the base, where the mucosa showed a moderate amount of congestion. Sections of the obliterated portion did not even show the usual brown centre where the mucosa had disappeared. The patient reported April, 1932, complete relief from symptoms.



FIG. 15.—Mr. E. S. (A432), aged thirty-five years. Operation April 3, 1926. The appendix was eleven centimetres long, smaller than normal. The tip had narrowed to a filament. This area was removed without the peritoneal covering. From the tip toward the base the appendix tended to become larger. On section the lumen appeared to be obliterated throughout to within about one centimetre of the base, where it flared out into the cæcum.

CASE IV.—Miss L. M. (Case No. A657), aged fifty years. One month before admission, following an attack of influenza, the patient had a chill, nausea, and tenderness in the abdomen most marked on the right side. This persisted until operation, May 3, 1926. The appendix was 8.5 centimetres long, somewhat smaller than normal. There were no adhesions or congestion. The appendix was very firm. On section the lumen was practically obliterated throughout. Patient reported April, 1932, complete relief from symptoms.

CASE V.—Mrs. W. L. B. (Case No. A2582), aged thirty-three years. For four years before admission the patient had been having recurring attacks beginning with cramps in the "pit of the stomach." She would have a sensation of fullness, become nauseated but could not vomit. She had hot and chilly sensations. She would then get better and the pain in stomach would leave, but there would be a dull ache and soreness in the lower abdomen on the right side. Her last attack was five months before admission; since then there had been definite tenderness in the right lower quadrant. On physical examination there was tenderness on pressure in the right hypochondriac region, with some muscle spasm over the right iliac fossa. Appendectomy March 6, 1928. The appendix was somewhat adherent in the mesenteric border, 10.5 centimetres long, smaller than normal, and had a very fat mesentery. There was no congestion. On section the appendix seemed to be completely obliterated from the tip

to the base, where there was a small lumen and thin mucosa. Patient reported April, 1932, that she was unimproved.

CASE VI.—Mr. J. C. C. (Case No. A2614), aged twenty-seven years. For the past two years he had had attacks of "indigestion" and had had a dull ache in the region of the appendix which had been fairly constant. He had not been constipated. Three days before admission the patient had cramp-like pains in the region of the umbilicus, which seemed to radiate upward. He was nauseated and vomited. The cramp subsided but left a dull ache in the right lower abdomen. Abdominal examination showed moderate tension with no distention, and distinct tenderness on deep pressure over the right iliac fossa. Appendectomy March 15, 1928, with division of Lane band. The appendix was 3.5 centimetres long, smaller than normal, of whitish color, and presented no evidence of adhesions. On section it appeared to be obliterated throughout, even at the base, and the mucosa had disappeared. Patient reported April, 1932, complete relief from symptoms.

CASE VII.—Mrs. H. M. (Case No. A2681), aged forty years. The patient had an attack of acute appendicitis twenty-four years previously. Since then she had been having recurring attacks of indigestion with generalized pain, some nausea and soreness in the right iliac fossa. These attacks had been closer together for the past several months and she had had a more or less constant pain in the right side. There was some gas and distention after eating. Constipation was present. Physical examination showed marked spasm and some tenderness in the right iliac region. Appendectomy April 5, 1928. The appendix was five centimetres long, smaller than normal, slightly congested, and presented marked evidence of adhesions. On section it was firm and cord-like throughout. Patient reported April, 1932, complete relief from symptoms.

CASE VIII.—Miss A. C. (Case No. A3327), aged seventeen years. Four days before admission the patient had pain in the right side which remained in the same location, growing increasingly worse. On the third day she became nauseated and vomited. She had had previous attacks of the same kind. Physical examination showed tenderness in the right lower quadrant with muscle spasm of the right rectus muscle and over McBurney's point. Appendectomy September 17, 1928. The appendix was nine centimetres long, smaller than normal, markedly adherent throughout. It was firm and cord-like. On section it seemed obliterated throughout. Patient reported April, 1932, complete relief from symptoms.

CASE IX.—Mr. C. F. J. (Case No. A3934), aged thirty-two years. The symptoms began about eight years ago, with indigestion and pain which would seem to radiate to the right lower quadrant. He had been having recurrent attacks of indigestion, gas and constipation over a period of six years. About a month before admission the patient had some nausea, and pain in the right lower quadrant. Two and a half years previously there had been an attack of jaundice, when the patient remained in bed for two weeks and was jaundiced for about six weeks. Physical examination showed the abdominal muscles with increased tone, and slight tenderness in the region of the right iliac fossa. There was some tenderness in the region of the gall-bladder. Appendectomy, and exploratory of upper abdomen, March 23, 1929. The gall-bladder appeared normal. The appendix was four and one-half centimetres long, presented evidence of adhesions near its base, and was not congested. It was quite firm. The tip was larger than elsewhere. On section the lumen seemed to be almost obliterated throughout. The wall was thick and presented the appearance of obliterative appendicitis. Patient reported April, 1932, that he had been improved by the operation but still had some symptoms.

CASE X.—Mrs. J. B. (Case No. 8172), aged fifty-three years. The patient was admitted to the hospital as an emergency. Ten days before admission there had been a dull pain over the entire abdomen. This localized in the right lower quadrant the day before admission. There was nausea with no vomiting. There was a history of previous attacks. The patient was not constipated. Physical examination shows rather

CHRONIC OBLITERATIVE APPENDICITIS

acute tenderness and decided muscle spasm in the right iliac fossa. The point of tenderness seemed to be about half-way between the umbilicus and the anterior-superior spinous process. Appendectomy, June 16, 1929. The appendix was seven and one-half centimetres long, somewhat smaller than usual and larger in the distal half than in the proximal half. Near the tip there was slight congestion, but the appendix throughout was firm and almost white in color. On section the mucosa seemed to have disappeared and it presented the typical appearance throughout of obliterating appendicitis. Patient reported April, 1932, complete relief from symptoms.

CASE XI.—Mr. H. G. S. (Case No. A4890), aged forty-six years. Several years ago the patient had an attack of very severe pain in the right lower quadrant, accompanied by nausea and vomiting. He was confined to bed. There were two similar attacks later. About two months before admission he began to have a dull ache in the right side; he was confined to bed for a while; the pain was usually dull but at times there were sharp, stabbing pains which radiated across the lower abdomen.



FIG. 16.

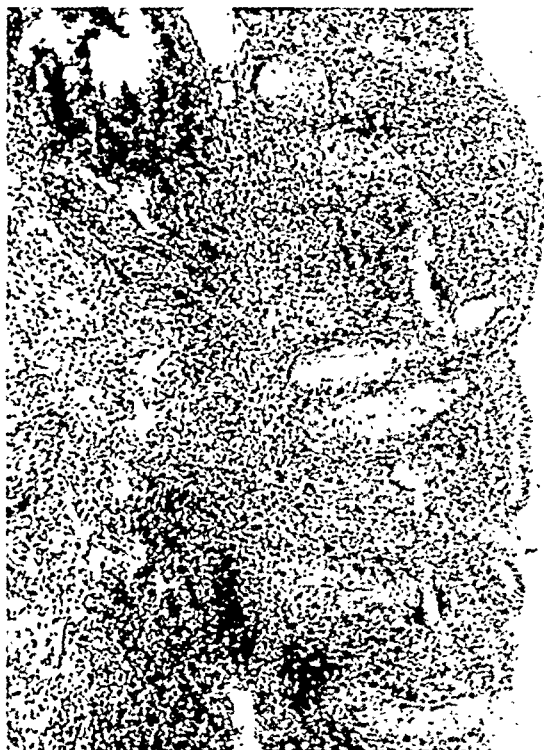


FIG. 17.

FIG. 16.—(Case XII.) Mr. O. A. R. (A6086), aged thirty-three years. Operation January 26, 1931. The appendix was eleven centimetres long, smaller than normal, and obliterated practically throughout except for a short distance near the base. Longitudinal section at the base shows leucocytic infiltration of the mucosa near the obliterated portion. (x 18.)

FIG. 17.—Higher magnification of the blocked-out area in the preceding figure, showing the mucosa at the junction with the obliterated portion. (x 100.)

He had been unable to work for some time. On physical examination there was definite tenderness over the upper portion of the right lower quadrant. Appendectomy January 3, 1930. The appendix was six centimetres long, somewhat smaller than normal, and quite firm. It presented evidence of almost universal adhesions. On section the lumen was almost obliterated throughout. Patient reported April, 1932, complete relief from symptoms.

CASE XII.—Mr. O. A. R. (Case No. A6086), aged thirty-three years. (Figs. 16, 17, 18 and 19.) The symptoms began about ten months before admission, and lasted for six weeks, with cramping pains in the epigastrium and sometimes in the right side. Then there was a remission until seven months later and this time the pain was more localized in the right side. There were several attacks following this, and two or three days before admission he had had an attack of epigastric pain accompanied by

nausea and vomiting, with pain gradually localized in the right lower quadrant. On physical examination there were slight pain and discomfort in the epigastric region, and some pain on deep pressure in the right iliac fossa. Appendectomy January 26, 1931. The appendix was adherent, eleven centimetres long, rather smaller than normal, somewhat congested and firm. On section the lumen seemed to be almost obliterated, closed except at the base. Patient reported April, 1932, that he was improved by the operation, but still has some symptoms.

CASE XIII.—Dr. C. G. F. (Case No. A6925), aged twenty-five years. The patient had been feeling generally below par for the past week, but had not completely recovered from a head injury with anaphylactic shock from tetanus antitoxin several months earlier. He complained of severe colicky pains over the abdomen and definite arthritic pains in the right knee. The urine was cloudy and contained some blood. The abdomen showed generalized distention with very definite pain on moderate pressure in the left lower quadrant and left upper quadrant, and, to a less extent, in the right



FIG. 18.

FIG. 18.—Cross-section of appendix of Mr. O. A. R. (A6086). The muscular coat is fairly well preserved, the lumen occupied by trabeculated connective tissue resembling that in Figs. 10 and 11. (x 18.)



FIG. 19.

FIG. 19.—Blocked-out area in the preceding figure, showing infiltration with inflammatory products of tissue occupying the former lumen. The surrounding area was apparently filled with fat; the lumen had disappeared. (x 100.)

lower quadrant. The pain later definitely localized over the appendix. Appendectomy and separation of adhesions to the ascending colon, September 7, 1931. The appendix was eight centimetres long, smaller than normal and congested. It was somewhat adherent to the cæcum. On section it presented the appearance of obliterative appendicitis throughout. The peritoneal coat was markedly congested. The patient reported April, 1932, that he is improved and has had none of the attacks of pain which he had before operation, but has some gastro-intestinal symptoms resembling those of colitis.

CONCLUSIONS.—(1) Chronic obliterative appendicitis is the result of a chronic inflammatory process that tends to destroy the mucosa and obliterate the lumen of the appendix. It may last for many years.

CHRONIC OBLITERATIVE APPENDICITIS

(2) It may exist in any stage, from involvement of a small portion at the tip to complete obliteration of the entire lumen of the appendix.

(3) It may be found at any age, from five years upward, but is more frequent in the elderly, probably because they have had longer opportunities for attacks of inflammation.

(4) Acute appendicitis or even rupture of the appendix may occur in an appendix that has been partially obliterated.

(5) In a small series of cases (thirteen) in which there was completely obliterative appendicitis and in which the operation was solely for appendicitis, there were definite symptoms before operation. Eight of these patients have been entirely relieved of their symptoms, three of them have been partially relieved, and two were not relieved. Complete obliterative appendicitis may produce marked symptoms which may be relieved by removal of the appendix.

(6) While a complete obliterative appendicitis seems incapable of producing a serious peritonitis, it may cause discomfort that can be relieved only by operation. An accurate diagnosis of chronic obliterative appendicitis is difficult until the abdomen is opened, and right-sided lower abdominal pain should be carefully investigated before any such diagnosis is ventured. Ureteral lesions, a small hernia, ulcers in the terminal ileum or cæcum, arthritis or lesions of the spine, and disease of the sacro-iliac joint, should be considered before assuming a clinical diagnosis of chronic obliterative appendicitis.

BIBLIOGRAPHY

- MacCarty, W. C., and McGrath, B. F.: Clinical and Pathological Significance of Obliteration, Carcinoma and Diverticulum of the Appendix. *Surg., Gynec., and Obst.*, vol. xii, pp. 211-220, March, 1911.
- Pfeiffer, D. B.: Appendicular Obliteration. *Tr. Phila. Acad. Surg.*, vol. xvii, pp. 238-245, 1915.
- Moschcowitz, E.: The Pathological Diagnosis of Disease of the Appendix Based on the Study of 1,500 Specimens. *ANNALS OF SURGERY*, vol. lxiii, pp. 697-714, 1916.
- Ribbert: *Virchow's Arch.*, 1893.
- Cabot, Hugh: Chronic Appendicitis, the Scapegoat of Abdominal Surgery. *Jour. Michigan State Med. Soc.*, vol. xii, pp. 452-456, 1920.
- Masson, P.: Sympathetic Neuromas of Appendicitis. *Lyons Chir.*, vol. xviii, p. 281, Lyons, May-June, 1921; *Abstract Jour. Am. Med. Assn.*, p. 652, August 20, 1921.
- Royster, Hubert A.: Appendicitis. D. Appleton Co., pp. 75-76, New York, 1927.
- Hellwig, C. Alexander: *Am. Jour. Obstet. and Gynec.*, vol. xviii, pp. 332-341, September, 1929.

ACUTE APPENDICITIS—A BRIEF CRITICISM

BY FRED WARREN BAILEY, M.D.

OF ST. LOUIS, MO.

THE mortality rate in acute appendicitis is appalling. The degree of professional dissatisfaction is indicated by the fact that, within the last two years, over 500 papers on this disease have been published. Jeff Miller¹ aptly terms the high death rate "a menace to humanity, a disgrace to the medical profession and a challenge to us who claim to practice the science and art of surgery." The medical profession has as yet never failed to fight any encroachment upon their right to serve humanity.

Willis,² in 1926, reported a marked increase in mortality rate averaging 14.5 per cent. per 100,000, 80 per cent. of all deaths occurring before the fiftieth year, or during the productive period of life. He emphasized the fact that "deaths from appendicitis equal all those from salpingitis, pelvic abscess, surgical diseases of the pancreas, spleen, thyroid, gall-stones, gastric and duodenal ulcers."

Coller and McRae,³ after a most careful statistical study, found a steady increase in fatalities in the last twenty years. In 1926, over 18,000 died as a result of appendicitis.

Bankhead Banks⁴ states that the mortality rate was 50 per cent. higher in 1928 than in 1915, and that prior to the age of fifty, four times as many die from appendicitis as from cancer.

John B. Murphy,⁵ in 1894, soon after perityphlitis and bowel-block had merged into perforated appendicitis, wrote: "There is no palliative excuse for a mortality of 10 per cent. in appendicitis. It is so common and so important a condition that the indications for its treatment should and must be a matter of common knowledge among doctors and laymen."

A cross-section of an exhaustive statistical review shows a general average of from 9 per cent. to 18 per cent. in all cases of perforated appendicitis, and from less than 1 per cent. to 18 per cent. in all types of the disease. Results as well as statistics will be influenced by many circumstances. Ideal hospitals, flawless surgery, and dependable surgical judgment may not be the boon of even a majority of the operated cases, but even with every favorable facility in hospital care and surgical technic we have failed with few exceptions, to reduce the mortality of this disease which is so simple in origin, so persistent in its warning and so fatal in the face of neglect.

The cause of our failure has long been known. John B. Deaver spent a part of every work-day denouncing delay in diagnosis and treatment of appendicitis as a pertinent factor in high mortality.

Throughout the last thirty years most surgeons of note, many of whose names grace the roll of this Association, have urged early diagnosis and

prompt operation in all acute attacks. Delayed diagnosis may become a fatal professional error. A clinically acute abdomen may not always present "classical symptoms," nor can the human individual be standardized as to his susceptibility to disease, nor as to his protective power in the presence of infection. Acute appendicitis may inflict greater damage and danger in ten hours upon one individual than in thirty hours upon another. There is no definite "period of safety" in any acute attack of appendicitis, nor is there any unerring index that marks the true course of the disease. All attacks, mild or severe, are tentative contributors to the disgraceful mortality rate which we view with a sense of professional shame.

John Bower⁶ surveyed twenty-seven hospitals comprising all grades; he reviewed 6,123 cases with a resulting range in mortality from 1.64 per cent. to 11.29 per cent. Obviously, the fatality rate was lower in carefully supervised hospitals with highly trained physicians in attendance. The average lapse of time between initial symptoms and hospital admittance was 61.17 hours. The mortality rate ranged from 2.55 per cent. for those in hospital within twenty-four hours to 11.83 per cent. for those after seventy-two hours or three days. One out of every eighteen admitted to a modern city hospital is marked for death; over 80 per cent. of those who die perish from peritonitis, and finally, that of all who were hospitalized and operated within twelve hours of the initial attack, 99 per cent. recovered.

In one hundred cases of ruptured appendicitis with peritonitis operated upon by the writer, showing a range of age incidence from two to eighty-two years, the average duration of the disease before hospitalization was 5.4 days. Sixty-six had suffered previous attacks; nine of the twelve who died were from this group. Over two-thirds of the 100 cases had been given "home treatment" with laxatives, food, and sedatives, without medical aid. It is unnecessary to direct your attention to the truth that over 99 per cent. of the fatal cases are of those who have been home treated, or mistreated, for from three to six days before hospitalization. Such death-dealing action on the part of the family is not attributable to indifference or intentional neglect, but to ignorance of the actual menace of the disease. To this may be added an inherited fear of hospitals, and of the doctor who believes in operating. Economic conditions often enforce delay. Newspapers, although totally uninformed as to the circumstances, complications, or physical state of the subject, are prone to feature in broad headlines all deaths that occur following operation, in such a manner that the laity condemns the operation, not the delay and the faltering vitality, for the failure. Because of the fear thus engendered, surgery is to them the last resort and is strenuously avoided. From the present viewpoint of a layman we would draw the same conclusions.

Throughout the fifty years that appendicitis has been an acknowledged surgical affection, in our fervor to perfect our abdominal technic, we have given too little heed to the pre-operative period of the disease. It is this variable period of home treatment that renders so difficult the best efforts of the surgeon. It cannot be denied that the recovery rate in cases operated upon

at any stage of the attack depends largely upon surgical judgment and errorless technic, and that the surgeon, in knowing when to operate, what to do and what not to do with the late case, will rate a lower mortality.

In the present day, surgeons are plentiful and convenient; many of them are excellent, many striving to be, many content to remain as of yesterday, but most of them thoroughly capable of safely removing an uncomplicated six- to twelve-hour appendix. Therein lies one thought I wish to emphasize. If we earnestly desire to reduce our mortality in appendicitis to the minimum, the operation, if needed, must be performed before dangerous complications have developed. To accomplish this the diagnosis must be made early and carefully by a physician who is alive to the danger. That this may be realized, the doctor must be permitted to see the case during the period of comparative safety, within six to ten hours of the onset. When seen thus early, transportation to any distance necessary for satisfactory hospital and surgical service is practicable. This will not be accomplished without intensive lay instruction.

In 1879, fifty-three years ago, when Nicolas Senn⁷ wrote "All cases of catarrhal and ulcerative appendicitis should be treated by laparotomy and excision of the appendix as soon as the lesion can be recognized," he was inviting early diagnosis and preventive surgery, our present theme.

Until the last few years public instruction in things medical was rather sharply limited to cancer, tuberculosis, diphtheria, smallpox and kindred diseases. True it is, that sporadically here and there arose a warning and admonition that we must recognize and operate early if we hoped to curb the death rate of appendicitis. The major part of our interest in the past has been centered on how best to conduct a case that has become critically ill. It is incumbent upon us to prevent the critical period.

The Journal of the American Medical Association and the American College of Surgeons long ago recognized the need of broad intensive lay education. Hygeia has presented many valuable lay articles, but it has reached too few families to reap the benefit the gesture merits. The radio has very likely been the most effective medium of broad dissemination, and occasional broadcasts from local medical societies or major medical conventions have created increased public interest. Insurance companies of high standing have made a more direct appeal to the reading public through paid advertising; their effort to conserve life and health deserves admiration and commendation. No motive may be fairly termed ulterior when its objective is preservation of life. There are still many simple and effective avenues of approach in lay education and many valid reasons why they should be utilized. The situation demands that each family be taught the potential danger of persistent abdominal pain and that they must promptly place the responsibility of the diagnosis and treatment upon their physician.

It will not be necessary to *force* this knowledge upon the public. The educational newspaper articles written by Doctor Fishbein on various health subjects have attracted wide attention. Not less than five such articles have dealt with appendicitis. He writes: "I am convinced that education of the

public, is probably our greatest hope in controlling increased mortality from appendicitis."

Olin West, Secretary of the American Medical Association, informs me that the publication of articles on appendicitis in *Hygea*, and elsewhere, although reaching a very limited part of our public, has brought thousands of inquiries from its readers. He also states that this contact with the public on things medical constitutes an important part of the association's work; that one department alone answers from six to ten thousand inquiries a year from laymen, while thousands of others are answered in other departments. The thinking public is eager for a better knowledge of how to care for themselves and their children. From a humanitarian as well as an economic angle, with but few exceptions, they will welcome every aid toward preservation of life and health.

Ten years ago, before the Southern Surgical Association, the writer⁸ presented a paper on "Errors in the Home Treatment of Appendicitis." A very definite period of home treatment invariably intervenes between the onset of disease and the physician's entry. It was my contention then, as now, that the high mortality rate in appendicitis is largely determined by the conduct of the attack before the doctor is called. Unfortunately, there are still a few doctors who will prescribe for colic by telephone, or send a sedative, or order a purge, or procrastinate in diagnosis, just as there are also many citizens who decry doctors and drugs until the fatal issue is apparent even to them; but a standard of action cannot be predicated upon the exceptions to the rule. An understanding public will welcome frank discussion of subjects inimical to their health and happiness. The physician, called early, will have sufficient time to work out a careful diagnosis, and, if necessary, to safely hospitalize the patient, and the surgeon will welcome the opportunity to forestall a peritonitis and the disastrous sequelæ that often follow. The economic saving to a community, in life and morbidity alone, will well compensate the efforts of all who participate.

Each year, the College of Surgeons holds community health meetings at all sectional and national conventions; public halls have been unable to accommodate the attendance. Radio talks on nation-wide hook-ups are given. Trained speakers cover senior high schools, junior colleges, community service clubs, and women's organizations on appendicitis, cancer and other diseases where fore-knowledge is of value. The public is ready to receive, the profession should be willing to give.

Our recognition of this challenge has been deplorably slow. John B. Murphy, that dynamic teacher and clinician, who more than any other of his period urged the substitution of prompt surgery for watchful waiting in acute appendicitis, said: "I desire to urge upon you, first, that you operate upon all frank cases; second, that you operate early to save yourself the humiliation of performing an ante-mortem operation." Our mortality, despite the medical and surgical progress, within the last fifty years has increased, and the

train of crippling sequelæ in those who survive a vicious attack constitutes an additional serious problem.

It was not my desire to include in this paper any discussion of the operative or post-operative stages of appendicitis, although the supervision of both periods of the disease is of most vital influence in controlling mortality. It is tenable to assume that surgical judgment must be fitted to each individual case; that standardization of surgical treatment is unwise; that the present knowledge of sound technic and after-care will probably admit of but minor improvement as time goes on, and that primarily our hope must lie in an attack upon the true source of the high mortality, the first stage of the disease, and secondarily upon the general adoption of the most effective surgical technic in the neglected case.

Mature judgment during the operative stage is invaluable; neither radicalism nor timidity will best serve routinely. An active peritonitis demands a higher degree of mental balance than technical skill. In the opinion of Deaver,⁹ precipitate or too radical removal during peritonitis and failure to insist on removal of the interval appendix are factors of great importance.

Charles Mayo¹⁰ criticizes the tendency toward "radicalism during the danger stage and delayed or mistaken diagnosis."

Le Grand Guerry,¹¹ in reporting an enviable record of recoveries in acute diffuse peritonitis, selected his time and method of operation with extreme caution, dealing with each case on its own merits, with the most encouraging results yet reported.

The complications that so generously affect the mortality rate are numerous; peritonitis, ileus, residual abscess, and pylephlebitis probably lead the field. Post-operative hernia, obstruction from adhesions, thrombosis, embolism and intestinal fistulæ, exact a definite toll and increased morbidity. Lay education will undoubtedly reduce in quantity a most interesting phase of our surgical activity, as well as allay many of our most serious operative and post-operative worries.

Of the 500,000 cases of appendicitis reported in the United States in 1925, it may be definitely assumed that of the 25,000 who died more than 20,000 might have been saved had the victims had the services of an intelligent physician within the first six hours of the attack. This can be made possible only by a systematic, intelligently supervised program of lay education. It is natural that exception be taken to the dearth of scientific interest in this paper, and for that omission I most humbly apologize, yet my conception of the duty of a surgeon encompasses a broader and more humane field than may be sheltered under the banners of science and art. None is more anxious to save the lives of thousands of our citizens than the surgeon, even though the method entail no more thrilling nor heroic act than the substitution of a preventive early operation, with a negligible mortality, for a late and often incomplete one, with its high death rate and long trail of menacing after-effects. We have known for years that many lives would be saved by early operation. We have felt and known that ignorance of the danger caused

the delay, and that education alone would dispel that ignorance. We have probably felt that our dignity might be best conserved if we maintain an inherited scientific restraint and permit the family doctor to spread the protective gospel.

Preventive surgery is scientific progression, and is as truly essential as preventive medicine. In my humble opinion it should be accepted as a privilege as well as a scientific duty to join hands, by commission or otherwise, as suggested by Willis, with other medico-surgical and civic bodies to work out a plan whereby a dignified, intensive, self-accelerating program of general education upon the danger signs of this and other highly fatal diseases may be instituted. We would go to any extreme of effort to reduce the mortality of cancer were we privileged to do so. The dissipation of high mortality in appendicitis is equally important to the public welfare and far more promising of immediate results. Any preventable scourge that claims a citizen of the United States every twenty-five minutes of each day merits any effort or method to subdue it.

Thoughtful consideration is being given in various communities to the most simple, practical and effective method of presenting gratuitous advice to the public. In a certain community in Pennsylvania the profession has repeatedly broadcast by radio the common error of delaying the call for the doctor in the presence of persistent abdominal pain. A program is in effect that will insure information to every family.

Royster,¹² who has repeatedly reminded us of the potential danger of the pre-medical period, suggests unified action by local medical societies, health boards, civic organizations, schools, public health nurses, druggists, *etc.*; in others words, utilization of all existing groups that are already actively functioning and interested in public service. Now and then we find to our discomfiture that a doctor has been in attendance and has failed, through various reasons, to note the progress until too late for safe operation, or has mistaken the ailment for one of the many that, in the early period, may simulate appendicitis. Our medical schools and medical journals can reduce these errors to the minimum by reminding the physician that frequent inspection in suspected appendicitis is far less expensive than prolonged care after rupture has swept away the possibility of safe and prompt recovery. Doctor and laymen alike must know that the peristaltic urge of castor oil and its fellow assassins, given by loving relatives in forgivable ignorance, drives many mild attacks into fulminating activity.

If the combined medical and surgical profession will thus sanction and supervise an earnest effort to control the death rate in acute appendicitis, within five years a reduction to an insignificant rate will have been achieved, without stigmatizing our surgical pride or lowering the standard of our professional service.

In closing permit me to read an impressive admonition from the pen of a layman written eighty-six years ago: "The human race is afflicted with disease. Mankind as a body are sick and need a physician. They need effectual atten-

tion, and permanent restitution to health, energy and happiness. The race, then, must be educated. The rudiments of this education must consist in each one knowing himself in every essential anatomical and physiological particular, and then the world will not be cursed with ignorance, vice, disease and misery. Then physicians will be useful and beneficial, for their time and talents will be concentrated in the great work of social and moral reform, and their interests will not only consist in the amount of health enjoyed, but in the destruction of ignorance, violation and local wretchedness."

SUMMARY

The mortality rate in acute appendicitis has increased during the last two decades.

Medical and surgical care has vastly improved during this period without corresponding reduction in mortality.

There is less than 1 per cent. mortality among those operated upon within the first twelve hours of the attack. The average length of time consumed in nefarious home treatment without medical aid is from sixty to eighty hours. The mortality rate among those whose hospitalization has been delayed beyond thirty-six hours is 11 per cent., to 18 per cent., presenting a difference of from 10 per cent. to 17 per cent. as a result of unnecessary delay. Peritonitis is the cause of death in over eighty per cent. of the fatal cases. Operative care and surgical judgment are of extreme importance in the neglected case. Aside from this, the actual cause of death in acute appendicitis is public ignorance or disregard of the potential danger of abdominal pain, and unintentional mal-treatment before the physician is consulted.

Preventive surgery is operation of frankly surgical conditions before a critical state has developed.

Appendicitis is a surgical disease. It is the surgeon's duty to reduce the death rate wherever and however possible. In appendicitis, this reduction may be attained only by cautious operative technic and well-planned, intelligently directed lay education, which should be promptly instituted and promoted by all groups interested in public welfare.

BIBLIOGRAPHY

- ¹ Miller, Jeff: Jour. C. of S. Australia, vol. iii, p. 40, 1931.
- ² Willis, Murat: Surg., Gynec., and Obst., March, 1926.
- ³ Collier, and McRae: Mich. State Med. Jour., May, 1931.
- ⁴ Banks, Bankhead: West Virginia Med. Jour., July, 1930.
- ⁵ Murphy, John B.: Pan-American Cong., 1894.
- ⁶ Bower, John O.: Jour. Am. Med. Assn., May 2, 1931.
- ⁷ Senn, Nicholas: Jour. Am. Med. Assn., vol. xiii, p. 630, 1889.
- ⁸ Bailey, Fred. W.: So. Surg. Trans., vol. xxxv, 1922.
- ⁹ Deaver, John B.: Pittsburgh Ac. of Med., February, 1928.
- ¹⁰ Mayo, Charles: Jour. Am. Med. Assn., vol. lxxxiii, 1924.
- ¹¹ Guerry, Le Grand: ANNALS OF SURGERY, vol. lxxxiv, p. 285, August, 1926.
- ¹² Royster, Hubert: Pennsylvania Med. Jour., March, 1931.

TREATMENT OF APPENDICITIS COMPLICATED BY PERITONITIS

BY ARTHUR M. SHIPLEY, M.D. AND HUGH A. BAILEY, M.D.
OF BALTIMORE, MD.

FROM THE DEPARTMENT OF SURGERY OF THE UNIVERSITY OF MARYLAND

SINCE Fitz established the real nature of appendicitis in 1886, many hundreds of papers have been written on the subject and more operations for appendicitis have been done than for any other malady. It would seem, therefore, that the entire subject should be exhausted, the mortality lowered year by year and the operative treatment of the disease and its complications standardized. This is far from the truth, however. Appendicitis and its complications are still subjects of controversy, there is much difference of opinion and practice, and the death rate is on the increase.

The mortality of appendicitis is a subject about which there is deservedly a great deal of thought and discussion. Clean appendectomies have an almost negligible death rate. When the peritoneum becomes infected the mortality in different reports varies between 10 per cent. and 22 per cent. Here is a sharp and fatal difference in mortality and a number of writers have raised the question as to just how much drainage material actually aids in draining the peritoneal cavity and to what extent intestinal obstruction, caused by drains, contributes to the death rate.

These cases of peritonitis complicating appendicitis might be divided into three groups: First, early peritonitis, where the exudate is chiefly liquid and may be scanty or abundant, localized, spreading or diffuse; where the gut is injected and somewhat œdematous, but where the surface of the intestine is still smooth and for the most part shiny. Second, late diffuse peritonitis with the coils of the intestine everywhere adherent, with many small pockets of pus scattered widely and the intestine red and dull. Many of these patients die no matter what is done. Third, walled-off infected areas, secondary to acute appendicitis, where the patient comes in the hospital with a palpable mass, and, if operated on cautiously, and if the drains are confined to the walled-off area, give a good outlook as to life.

Sworn and Fitzgibbon¹ reported recently on appendectomies in St. Thomas' Hospital, London, over a ten-year period, 1920-1929 inclusive. There were 2,126 cases in which there were 231 cases of diffuse peritonitis divided into one-, two-, three- or four-day cases, with a death rate of about 19 per cent. In 487 patients with a palpable mass there were only seventeen deaths, a death rate less than 4 per cent. In the 1,340 patients without peritonitis the mortality was 1.71 per cent. From these figures and from many others that could be collected it is appallingly evident that peritonitis, as a complication of appendicitis, is a death-dealing malady.

In one group death is due directly to peritonitis and its contributing fac-

tors—paralytic ileus, dehydration, exhaustion, toxæmia and disturbance of the acid-base balance. In another group, death is caused by some complication—empyæma, pneumonia, infarction, septicæmia, *etc.*; and, in a third group, mechanical obstruction is the cause of death.

Cutting² recently said: "Post-operative ileus is due in almost all cases either directly or indirectly to peritonitis; about one-half of all cases of ileus are post-operative, and the condition of appendicitis accounts for by far the greatest number of cases of post-operative intestinal obstruction."

Just how many of the deaths following operations for appendicitis complicated by peritonitis are due to mechanical ileus it is impossible to say; certainly, a considerable number. When one considers that the average death rate for intestinal obstruction, exclusive of strangulated hernia, is about 50 per cent., this complication becomes a matter of grave concern.

We have been working, therefore, under the twofold risk of a spreading fatal peritonitis if we do not drain, on the one hand, and early or late mechanical ileus or disabling adhesions, following drainage, on the other.

When any operation is performed on tissues covered by the peritoneum this membrane insures a prompt sealing of the approximated wound edges. This is the keystone of abdominal surgery. But, this same beneficent and amazingly effective tissue, in the presence of drainage or infection, causes widespread adhesions which may lead to early or late intestinal obstruction.

Drainage is looked upon as a necessary evil. Every surgeon avoids it when he can and is fully alive to its risks and disadvantages. Its use is followed by many possibilities of mishap and misadventure—obstruction, paralytic ileus, adhesions, post-operative hernia, prolonged convalescence and fistulæ. There is scarcely a more disturbing time for patient and surgeon than the period following the placing of drains in the lower abdomen, especially if the patient develops distension, pain, vomiting and constipation. It is most difficult to know whether these symptoms are caused by paralytic ileus or by mechanical obstruction. To operate for paralytic ileus is to still further insult intestines already on a strike, and to fail to operate for mechanical obstruction is to deprive the patient of his chance of life. There is abundant experimental evidence that drainage material placed in the free peritoneal cavity does not drain the peritoneum. It becomes sealed off in a short time and acts only as an irritant around which omentum, mesentery and coils of intestine become adherent. In 1905, Yates³ showed the futility of trying to drain the peritoneal cavity by means of cigarette drains or tubes made of gauze. In every instance the drains were promptly shut off.

Poynter,⁴ in 1929, reported the experimental work of his department on peritoneal absorption and his findings were clear-cut as to the "reaction of the peritoneum to solutions and suspensions of particulate matter, to find out how absorption occurred and the paths taken." Bacteria and particles of matter found their way rapidly through the lymphatics in the diaphragm and entered the parasternal and paravertebral lymph-vessels. The process is rapid, beginning in three to five minutes. The only other channel of absorption dem-

onstrated was through the omentum. These methods of absorption were the same whether the peritoneum was normal at the time of injection or already inflamed.

Still more striking evidence of the ability of the peritoneum to care for itself when the cause of infection is removed, and of the ill-effect of peritoneal drainage in diffuse peritonitis was uncovered by Buchbinder, Droegemueller and Heilman,⁵ in 1931. They operated on thirty-one animals and left an open tube of gut attached to the mesentery, and restored the continuity of the gut above and below the open section by an end-to-end anastomosis; 90 per cent. of these animals died of peritonitis. They then operated on thirty-three animals, following the same procedure, and at the end of twenty-four hours excised the open section of gut in order to remove it as a further source of infection; fourteen of these animals recovered. They then operated on another twenty animals and performed the same two steps described above, except that they left two abdominal drains in each animal, one down toward the pelvis and the other in the upper abdomen. Two were lost during operation. The other eighteen all died on an average at the end of four days; seventeen died of peritonitis and the eighteenth dog of peritonitis and pneumonia.

Just what happens when a moderate amount of blood is left in the peritoneum is not certain. It has been generally supposed that blood and bacteria in the peritoneal cavity create conditions almost ideal for the development of peritonitis. Most of us have always drained the infected peritoneum if a reasonably dry field could not be obtained. Allen showed that infected blood injected into the pleura of rabbits produced empyæma in a large percentage of them. In spite of the above belief of surgeons and the experience of Allen, Sparks and David⁶ were unable to produce peritonitis in either dogs, rabbits or guinea-pigs, when autogenous blood mixed with broth suspensions of bacteria was injected into the peritoneal cavity.

There are a number of papers in which the authors take a decided stand in favor of closure of the abdomen in the presence of early spreading or diffuse peritonitis complicating appendicitis.

H. C. MILLER⁷ covered the subject very fully in 1930. He reviewed the literature, discussed the likelihood of drainage causing obstruction, and stressed the experimental evidence going to show how little actual drainage was done by drains in diffuse peritonitis, and concluded that drainage increases post-operative discomfort, prolongs convalescence and is a big factor in leading to secondary operations.

E. P. HALL, SR.,⁸ does not use drains for free pus in the peritoneal cavity and is confident that his mortality and morbidity rates have decreased. He drains all walled-in abscesses.

R. D. KIRK, JR.,⁹ thinks that the less drainage the better, and is confident that many bad results follow the introduction of drains among coils of intestines.

STANLEY RAW¹⁰ advocates closing the abdomen in all cases where the appendix has been removed. He has followed this method since 1921 and says there is less suppuration without drainage than with it.

B. BANKS¹¹ leans strongly to non-drainage in all spreading and diffuse peritonitis whenever it is possible to remove the cause.

MARCHINI¹² reported 301 cases of localized peritonitis; 184 were drained with nine deaths; 117 were not drained with two deaths. There were 142 cases of diffuse peritonitis; 101 were drained with thirty-one deaths; forty-one not drained with seven deaths. When these figures are consolidated, 158 patients with localized or diffuse peritonitis were not drained with nine deaths, a little less than 6 per cent. mortality; while 285 were drained with forty deaths, a fraction more than 14 per cent. mortality. We do not know how many of these forty deaths were caused by obstruction.

SWORN'S AND FITZGIBBON'S report is not so favorable to closure without drainage. Of 231 cases of diffuse peritonitis, 120 were not drained with twenty-one deaths, while 106 were drained with twenty-three deaths, the mortality in each group being about the same.

In 1921, ANDREW,¹³ of the Victoria Infirmary, Glasgow, closed seven cases of peritonitis without drainage after removing the appendix and making a clean toilet of the infected peritoneum, and leaving iodoform emulsion in this portion of the peritoneal cavity. They were also given *Bacillus coli* vaccine after operation; all recovered. There was some infection in the wound in three cases.

The reports from hospital laboratories as to the bacterial content of the exudate found in the peritoneum are often disappointing. Even when there is every optical evidence of peritonitis it often happens that the laboratory reports no growth. If we could have a group like that led by Dr. Frank L. Meleney,¹⁴ reports might show a more abundant and more varied peritoneal flora in peritonitis. Dr. Robert T. Morris, in discussing a paper by Dr. John E. Jennings, read before the New York Surgical Society, stated the entire matter with great accuracy. "Nowadays one who goes after any particular bacterium finds it by special methods."

Just putting some material from the peritoneal cavity into standard media and running it through the laboratory in ordinary routine will fail to recover many organisms that might be found. If the different organisms whose presence is either possible or likely were followed through by specially interested bacteriologists making use of special methods, the bacteriological findings would be more in keeping with the clinical appearance of the peritoneum at operation.

Until about two years ago I had been treating early peritonitis complicating appendicitis by drainage. These drains were introduced very much as we had been taught by the late Dr. Frank Martin. After removing the appendix through a McBurney incision two fingers of the left hand were introduced into the pelvis along the bladder wall, pushing the intestines back, and a small rubber tube and one small cigarette drain were introduced into the pelvis until the ends rested in the bottom of the peritoneal pouch in front of the rectum. Another cigarette or small rubber tube was placed lateral to the ascending colon with the end resting in the subhepatic space. The McBurney incision was closed snugly around these drains, and most of the patients made a prompt and satisfactory convalescence.

But there were a certain number who came to grief and in almost every instance intestinal obstruction was the complication present. Even when this condition did not actually exist there was often a period of uncertainty because of the presence of paralytic ileus or incomplete obstruction due to an-

gulation. In the spring of 1930, within a few weeks, four patients on whom I had operated for peritonitis following appendicitis and drained, developed mechanical obstruction and two of them died. At operation all four were completely obstructed by angulation of a loop of small intestines in the drain tract. The remainder of the peritoneum was free of adhesions or any evidence of infection. The possibility of intestinal obstruction following low abdominal drainage has always kept us anxious and apprehensive, especially if the drains were placed adjacent to coils of free intestine.

To close the abdomen, however, in the presence of peritonitis seemed a foolhardy thing to do, but less and less drainage was being used after pelvic inflammatory disease, intestinal suturing and cholecystectomies, and, being harassed by the imminence of obstruction, we began to close the abdomen after appendectomy where early peritonitis was present. At first we closed the seropurulent cases only, but as these patients did well, we gradually extended the list to include all cases of early peritonitis whether the appendix was thrombotic, gangrenous or perforated, and irrespective of the amount of fluid present or the extent of the involvement of the peritoneum.

This report is based on patients admitted to my service in the University Hospital, Baltimore, since June, 1930. Most of these patients were operated on by myself, although some of the operating was done by Dr. Hugh A. Bailey, who is the joint author of this paper and was resident surgeon last year, and Dr. George H. Yeager, who is the resident surgeon this year. Altogether, 251 patients have been operated on for appendicitis since this date, a period just short of two years. Of this number, seventy-two were chronic and 179 were acute. Of this latter number 113 patients were without any peritoneal involvement and were operated on in the usual manner. Eleven patients had late diffuse peritonitis and were drained. Four of these died; two of these four were reoperated on for intestinal obstruction. Seven came in with a mass and were drained with no deaths. There were forty-eight patients during this period with early peritonitis either local, spreading or diffuse. All of these abdomens would have been drained if we had been following our original methods. This group was closed without drainage following an operative technic to be presently described. There were seventeen positive cultures, fourteen of which were the colon bacillus.

There was no death in this group and no serious complication. There was no case that required a second opening of the abdomen for any cause and no extensive infection in the abdominal wall, although, as stated elsewhere, in a number of instances the abdominal wall was drained. There was a striking lessening in the severity and duration of paralytic ileus in these cases, and the convalescence was much shorter.

We have followed a definite technic in operating on these patients. We nearly always use the McBurney approach modified by a short transverse incision in the anterior sheath of the rectus muscle. This gives more room and an easier approach to an adherent or abnormally placed appendix. If the appendix is found thrombotic, gangrenous, or perforated, the wound edges are

protected by gauze. The peritoneum will take care of the infection much better than the structures of the abdominal wall. If the cæcum is mobile it is gently rolled out and the base of the appendix brought into view. Depending upon the mobility of the cæcum, and the length, position and fixation of the appendix to surrounding structures, this maneuver may be easy, difficult or impossible.

Whatever the condition found, an unhurried and painstaking attempt is made to free the appendix and clamp and cut its mesentery. Care is taken to handle the appendix with the fingers as little as possible. As soon as it is free, it is wrapped in gauze, delivered as well as possible, and removed. A careful closure and turning in of the stump follows. A very careful ligation of the mesenteric vessels is carried out. Raw surfaces are covered. This suturing is all done with fine silk, except the ligature on the appendix, which is catgut. The abdominal cavity is everywhere emptied of liquid exudate with the sucker. Most of the purulent matter is found in the pelvis and right iliac fossa. Very little packing is used; narrow retractors and spatulæ are used to get exposure. After the peritoneal cavity seems free of exudate, the appendix region and pelvis are exposed by using the fingers to push back the cæcum and small intestine, and warm normal salt is poured into this area slowly while the sucker pumps it out. If there are a number of small masses of coagulated fibrin adherent to coils of intestine, these are gently removed with moist gauze or smooth forceps. The peritoneum is then carefully closed, as a smooth peritoneum is the best guarantee against post-operative adhesions.

At this stage the towels are changed and the used instruments discarded, the gauze protecting the wound edges removed, the gloves changed, and the raw surfaces wiped over with alcohol, and, if much fat is present, with ether also, and the abdomen closed layer by layer. If the peritonitis has been extensive, with considerable coagulated exudate, and the appendix difficult of removal, a small tube drain is left through the fat down to the aponeurosis of the external oblique muscle.

We are anxious to be understood that all of these patients had acute appendicitis with early peritonitis. Sometimes the peritonitis was not suspected until the peritoneum was opened. They were not victims of longstanding infection. While the pulse rate was often rapid and the temperature and leucocyte count elevated, they were not dehydrated by vomiting and starvation but were, in the main, in good condition. When the abdomen was opened, although peritonitis was present and the intestines were injected and often somewhat dull and œdematous, they were not much distended or paralyzed, and there was no pocketing or walling-off. In a number of cases small patches of coagulated exudate were removed from intestines that had been in contact with the appendix, but in no case was this condition widespread.

Not all cases of suppurative peritonitis complicating appendicitis were

closed without drainage. There were a number of conditions in which drains were used. A considerable group of neglected cases of appendicitis came in with a palpable mass indicating usually a walled-off suppuration. These were drained and the rest of the peritoneum disturbed as little as possible. Sometimes in these cases it seemed wise not to look for the appendix unless it came readily into view. If the cæcum, after the removal of the appendix, could not be securely closed, a drain was left in. Sometimes the closure of the appendix stump was rendered more secure by suturing over it a bit of fat from the mesentery. If bleeding from the thickened, œdematous or short mesentery could not be entirely controlled, a small drain was left down to this area.

The most hopeless group were patients with late diffuse peritonitis, with adherent coils of intestines, walling-off many small pockets of pus, with the gut dull, red and distended, and covered here and there with masses of coagulated exudate. These patients presented the symptoms and signs of advanced peritonitis—a stiff, board-like abdomen, rapid pulse, drawn and anxious features, dehydration and disturbance in the acid-base balance. These were drained.

The important things in early peritonitis are not the kind and number of organisms in the peritoneum or the amount or extent of the exudate, but the source of infection, and whether or not the avenue through which the organisms are reaching the peritoneum may be promptly gotten at and closed. If this can be accomplished in the early stages of peritonitis, drainage need not be so widely used as has been practiced.

When the Fowler position came into vogue most surgeons used only dependent drainage and lessened the bulk of drainage material used. As the years passed it was observed that the long-continued Fowler position was associated with an increase in post-operative phlebitis and pulmonary embolism, and many surgeons were of the opinion that the jack-knife position predisposed to stasis of the venous circulation in the pelvis.

It is our belief that the improvement brought about by the Fowler position and dependent drainage was due in part to the simpler operation, relative absence of trauma, and the smaller and fewer drains, rather than to either the upright position or dependent drainage.

CONCLUSIONS

(1) Exclusive of strangulated hernia, peritonitis is the chief cause of intestinal obstruction.

(2) In the majority of instances, it is not the peritonitis *per se* that causes the adhesions and bands leading to obstruction, but the reaction of the peritoneum to the drains.

(3) Drainage material, especially in the lower abdomen, often causes widespread adhesions between loops of intestines, mesentery, omentum, pelvic organs and abdominal wall.

(4) Drains are soon sealed off and do not drain any considerable portion of the peritoneum.

(5) Paralytic ileus seriously obscures the clinical picture when drains are left in the abdomen.

(6) Pelvic drains increase the incidence of post-operative retention of urine.

(7) Drained abdomens are more likely to develop troublesome, painful, or disabling late post-operative adhesions.

(8) Late intestinal obstruction is more likely to occur in drained than in undrained abdomens.

(9) None of these considerations should carry any weight if the risk to life is increased by closure without drainage.

(10) Evidence is accumulating that the introduction of drains into the abdomen in the treatment of early peritonitis may be dispensed with, without increase in the death rate.

BIBLIOGRAPHY

- ¹ Sworn, B. R., and Fitzgibbon, G. M.: An Analysis of 2,126 Cases of Acute Appendicitis. *Brit. Jour. of Surg.*, vol. xix, p. 410, January, 1932.
- ² Cutting, R. A.: The Pre-operative and Post-operative Care of Patients with Intestinal Obstruction. *Amer. Jour. of Surg.*, vol. xiv, p. 703, December, 1931.
- ³ Yates, John L.: An Experimental Study of the Local Effects of Peritoneal Drainage. *Surg., Gynec., and Obst.*, vol. i, p. 473, 1905.
- ⁴ Poynter, C. W. M.: Peritoneal Absorption. *Nebraska State Med. Jour.*, vol. xiv, p. 362, 1929.
- ⁵ Buchbinder, J. R., Droegemueller, W. A., and Heilman, F. R.: Experimental Peritonitis, III. The Effect of Drainage upon Experimental Diffuse Peritonitis. *Surg., Gynec., and Obst.*, vol. liii, p. 726, December, 1931.
- ⁶ Sparks, Jos. P., and David, Vernon C.: Effect of Blood in the Peritoneal Cavity upon the Production of Peritonitis in Animals. *Surg., Gynec., and Obst.*, vol. xlviii, p. 780, 1929.
- ⁷ Miller, H. C.: The Problem of Draining the Peritoneal Cavity. *Nebraska State Med. Jour.*, vol. xv, p. 401, 1930.
- ⁸ Hall, E. P., Sr.: Why Do We Drain the Abdominal Cavity in Peritoneal Infection? *Texas State Jour. Med.*, vol. xxvi, p. 505, 1930.
- ⁹ Kirk, R. D., Jr.: Treatment of Acute Peritonitis. *New Orleans Med. and Surg. Jour.*, vol. lxxxiii, pp. 76-80, August, 1930.
- ¹⁰ Raw, Stanley: Eight Hundred Consecutive Operations for Appendicitis. *Brit. Med. Jour.*, vol. i, p. 483, March, 1930.
- ¹¹ Banks, B.: Factors Influencing Mortality Rate in Acute Appendicitis. *West Virginia Med. Jour.*, vol. xxvi, p. 403, 1930.
- ¹² Marchini, F.: Abolition of Drainage in Circumscribed and Diffuse Peritonitis, Especially from Appendicitis. *Surg., Gynec., and Obst.*, vol. liii, p. 330, October, 1931 (Abstract); *Arch. ital. di chir.*, vol. xxviii, p. 549, 1931.
- ¹³ Andrew, J. G.: The Operation for Acute Appendicitis: Primary Closure of the Abdominal Wound. *Brit. Med. Jour.*, vol. i, p. 1172, 1912.
- ¹⁴ Meleney, Frank L., Harvey, H. D., and Zern, Helen Z.: Peritonitis, I. The Correlation of the Bacteriology of the Peritoneal Exudate and the Clinical Course of the Disease in One Hundred Six Cases of Peritonitis. *Arch. of Surg.*, vol. xxii, p. 1, January, 1931.

TREATMENT APPENDICITIS WITH PERITONITIS

DISCUSSION.—DR. HUBERT A. ROYSTER (Raleigh, N. C.) said that for one who has spent many years and hard labor in the study of appendicitis and now feels that he knows less about it than ever, it is refreshing to see this subject on the program. In his belief it is not beneath the dignity of this Association to talk about appendicitis. In 1905, John B. Murphy shouted in one of his explosive efforts: "Is it time to stop talking about appendicitis? No, it is just the time to begin talking about it and talk about it most seriously and emphatically." That challenge is just as alive today as it was twenty-seven years ago.

Doctor Royster was afraid that as surgical teachers and operators this matter has been relegated to the pigeon-hole of solved problems while attention is being paid to what is regarded as more interesting and more modern matters. If one understands the pathology of appendicitis, one can solve most of the other problems. The whole question appears to centre around just this statement: That appendicitis is a going concern, a continuing process, and that the attack is not the disease but only the knock at the door, saying, "Let me out," and further, that every acute appendicitis attack, so-called, is a case in which there has been not only previous pathology but previous clinical symptoms which perhaps have not been recognized.

Doctor Royster was a disciple of Aschoff on this point: Whether one considers there is such a thing as chronic appendicitis or not, there has been chronic or continuing distress in the appendix before the so-called cardinal symptoms of the acute attacks are present, and in most diseases cardinal symptoms are merely terminal events.

Appendicitis obliterans, he believed, was first spoken of by Nicholas Senn, and whether one regards it as a physiological or pathological process, it is a question to determine whether the strictures produced off and on by the obliterating type of the disease, showing spaces between them, or becoming perfectly solid, are part and process of the real pathology which is in most cases in the wall of the appendix, and not in its lumen originally.

On the physiological side it might be explained somewhat by the work of Adami, who suggested that the appendix had a function which was to act as a hydrostatic propeller to throw the contents of the cæcum upward, and he called attention to the very marked peristaltic action in the appendix. A six-inch appendix removed immediately and placed on a glass table will within fifteen minutes contract about two inches of itself and when pulled out, will come to its original length.

If one considers that it has that action in the constant contraction and relaxation of the appendix in propelling the contents of the cæcum upward, it will so produce a chronic type of inflammation in its wall. In nearly all of these cases there are associated rings on the mucosa, which are very much like the rings in a tree, showing the number of attacks which the patient has had previously.

DR. EUGENE H. POOL (New York City) remarked that Doctor Shipley's paper suggested one or two things especially in regard to drainage. All accept the fact that the wound should be closed without drainage if it is reasonable; but a certain number of cases, as he says, must be drained. Now a word about the nature of the drains, but first in regard to the aspirator. Doctor Shipley makes a great mistake in irrigating within the peritoneal cavity. Blake advocated irrigation many years ago but he has since admitted the fact that it is a mistake.

Taking the nature of the drains in the cases where something must be introduced, Shipley referred to using a rubber tube down into the pelvis. Years ago it became evident that any kind of solid drain produces pressure necrosis, and is a very poor form of drain.

Many years ago when the speaker was house surgeon, and there were a large proportion of advanced and neglected cases of appendicitis to deal with, the incidence of fecal fistulæ was extremely high. It was suggested that perhaps the use of the

rubber tubes which was the custom favored these fistulæ. Soft rubber tissue drains were substituted with very marked reduction in the occurrence of fecal fistulæ.

In regard to soft rubber drains, they have found it advisable to introduce the so-called cigarette drain to the site which is to be drained. Recognizing that this in itself will not drain for long they therefore introduce another to the neighborhood of the site. The peritoneum is closed up to the drains to prevent omentum or intestine projecting along the side of the first drain. The second drain is removed in about thirty-six to forty-eight hours and it leaves a track along the side of the main drain or drains thus ensuring adequate drainage.

In badly infected cases only sufficient sutures are introduced to close the peritoneum beside the drains. The rest of the wound is left open; the reason for this is that when they did a partial suture above and below the drains in an appreciable number of cases there was found at the end of four or five days the typical colon infection and they had to open the wound, finding often sloughing of the aponeurosis of the external oblique. This is due to the tension of the sutures and the ready growth of the colon bacillus in the partially closed wound. When the wound is left open to the peritoneum there is no slough nor necrosis, as occurs with the colon infection. The wound rapidly granulates. No time is lost in convalescence and the incidence of incisional hernia is definitely diminished.

DR. LEONARD FREEMAN (Denver, Colorado) said that Doctor Horsley has called attention to obliterating appendicitis. Whether it is due to involution or to inflammation perhaps is not the important point. The important point is that a zone of inflammation is almost always present just in front of the obliterating portion of the appendix. The condition thus becomes a true chronic appendicitis manifesting itself constantly and indefinitely. The consequent symptoms may be due to several causes: to absorption by the blood-vessels; to inflammatory material; to the compression and irritation of the vegetative nerves and ganglia that Doctor Horsley has spoken of; or to lymphatic absorption.

PRIEBRAM, of Berlin, has called particular attention recently to lymphatic absorption and deserves our consideration. He speaks of the intricate ramification of lymphatics in the post-peritoneal area and how they connect up all the organs within the abdomen. When this network becomes infected, it may produce a great variety of symptoms in connection with these organs. The most obvious manifestation is enlargement of mesenteric lymph nodes, which in turn, may irritate the vegetative fibres still further, thus causing additional symptoms. Doctor Mayo has just called attention to this maze of lymphatic distribution within the abdomen.

It is not the acute form of appendicitis that causes this trouble; it is the chronic form. The acute form closes the lymphatics so that absorption does not occur into the post-peritoneal lymphatics; but the chronic form leads to absorption continuously over a great length of time, particularly the obliterating form, in which the disease may continue for months or even for years. When this lymphatic system is once involved the trouble does not always disappear when the appendix is removed. The same thing can be said of the gall-bladder, which is also a prominent port of entry into the lymphatic system as well as the appendix.

If this view is accepted it throws light on many symptoms, particularly those which often remain after the removal of the appendix. It also indicates that all chronic appendices, including the obliterating form, should, when encountered, be removed early and *completely*, because a small remaining stump may be the cause of persistent trouble.

DR. LE GRAND GUERRY (Columbia, S. C.) remarked that there is one great underlying principle in handling suppurative cases of appendicitis and this principle can be more clearly understood if one considers the background upon which it rests.

TREATMENT APPENDICITIS WITH PERITONITIS

His own experience may be tabulated as follows:

	No. Cases	No. Deaths	Mortality
(1) Recurrent appendicitis	1409	0	0
(2) Acute appendicitis	822	1	0.12%
(3) Gangrenous, ruptured, localized abscess	610	5	0.82%
(4) Gangrenous, ruptured, with diffuse peritonitis	93	10	10.75%
(5) Cases <i>in extremis</i> ; drainage; appendix not removed	9	3	33.3%
(6) Appendix removed in course of other operations	396	1	0.25%
	3339	20	0.60%

In the first group there are 1,409 cases in which the interval operation was done for so-called recurrent attacks of appendicitis without mortality. There were no deaths in this series. The only mortality connected with this type of case is the mortality incident to some unforeseen calamity. Occasionally a recurrent appendicitis in very stout people, in which the appendix is deeply placed and inaccessible, can be quite difficult.

In group two there were 822 cases with one death: a mortality of 0.12 per cent.

By the term acute is meant exactly what the word implies. This group includes all of the definite, unmistakably acute cases up to the point of perforation. Most of the appendices were the seat of definite gangrenous areas. No case was included in this group in which the appendix was actually the seat of perforation.

In group three there was gangrenous, ruptured appendix with localized abscess. In this group there were 610 cases with five deaths or 0.82 per cent. mortality. In a group of localized appendiceal abscesses of this size one would very nearly run the gamut of intraperitoneal suppuration.

In group four there was a gangrenous, or ruptured appendix with diffuse peritonitis; ninety-three cases with ten deaths or 10.75 per cent. mortality. The cases in this group were operated on immediately.

He would have occasion to refer to this group in his closing remarks for thereby hangs a tale.

In group five there were cases *in extremis*; drainage; appendix not removed; nine cases with three deaths or 33.3 per cent. mortality. He made a separate group of these nine cases for two reasons: First because they were well nigh moribund from long-continued suppuration, and secondly, they were the only cases in the entire series in which the appendix was not removed. The fact that the appendix was not removed may have had some relation to the mortality rate: on the other hand one could reason that the mortality might have been higher had the appendix been removed.

In group six there were 396 cases in which the appendix was removed in the course of other operations. This group is added to the study for the purpose of showing what relationship, if any, the removal of the appendix during the course of other operations has to the mortality rate. He had included in this group only the cases in which the appendix was unmistakably diseased: such an appendix as one would feel justified in removing were there no other operation necessary. It is not our practice now, nor has it ever been, to remove an appendix simply because we were in the abdomen and it could be done.

Taken out of the above résumé of cases is the following:

SHIPLEY AND BAILEY

	No. Cases	No. Deaths	Mortality
(1) Gangrenous, ruptured, localized abscess	610	5	0.82%
(2) Acute, diffuse peritonitis	93	10	10.75%
(3) Acute, diffuse peritonitis, deferred operation	128	2	1.5%
	<hr/> 831	<hr/> 17	<hr/> 2.05%

There is one series of cases in this grouping to which especial attention is directed and the group is presented with that purpose in view, *viz.*, the series of 128 cases of acute diffuse peritonitis in which operation was deferred. On the handling of these cases the question of the mortality rate largely rests. The whole question of mortality naturally hinges on the cases seen for the first time on the third or fourth day of the attack, cases with acute spreading infection. He emphasized particularly the point that none of these patients was operated on immediately; they were treated as outlined by Ochsner. With two exceptions, all were safely operated on at a later date; and in each case a gangrenous or ruptured appendix, with pus, was demonstrated at operation.

Contrast ninety-three cases of acute diffuse peritonitis operated on at once with ten deaths, or a mortality of 10.75 per cent., with 128 cases of acute diffuse peritonitis in which operation was deferred, with two deaths or a mortality of 1.5 per cent. Occasionally the Ochsner method has been supplemented by a simple incision and drainage under local anæsthesia, to relieve absorption from pus under tension.

These 128 cases in the statistics are included in the group of 610 localized appendiceal abscesses; likewise the two deaths which occurred previous to operation are included in the five deaths in the same series. These cases have been separated for the purpose of illustrating the difference between the mortality when the cases of acute diffuse peritonitis were operated on immediately and when operation was deferred.

In conclusion no claim is set up that this is the only way, or even the best way, to handle these critically ill patients. He simply presented a consecutive series of operations extending over a period of thirty years and is concerned with 3,339 cases. He emphasized the point that this mortality rate has been sustained throughout the entire time.

The one primary point that he was interested in making is this: If the work outlined above means anything it means that to do a formal operation on a patient critically ill with a diffuse peritonitis from a perforated appendix is to invite disaster.

DR. PHILEMON E. TRUESDALE (Fall River, Mass.) noted that the mortality in appendicitis among physicians is higher than in any other class of the population. In 1930, the mortality among doctors was twenty-five per 100,000, whereas among the general population it was eighteen.

In his own family, four children out of seven had been operated upon for appendicitis before the age of ten without incident. He believed that the twenty-five doctors who died in 1930 from this disease would be alive today if they had been operated upon in childhood, before they became so important and so enlightened that fear, conservatism, consultations, and business matters led the vast majority of them to procrastinate beyond the point of safety.

Unfortunately, in general, it seems necessary to appeal very strongly to the element of fear in order to get consent for early operation. Fear of death must first be instilled into the mind of the patient when he is seriously afflicted. Fear of the consequences of delay must be instilled into the minds of members of the family. Fear that delay will not pay in the long run must be instilled into the mind of the attending doctor. Finally, fear of postponing operation even for hours must be inculcated into the mind of the surgeon. He should be afraid of the consequences of too much surgery in cases where suppuration has occurred and the appendix is difficult to find.

TREATMENT APPENDICITIS WITH PERITONITIS

DR. FRANZ TOREK confined his remarks to one phase of the subject, "Diffuse Suppurative Peritonitis." This caption includes only those cases in which the purulent serum extends well over to the left side as well as to the upper abdomen and the pelvis. If a free purulent peritonitis extends only over a limited space, to the mid-line or slightly beyond, it should be called "Spreading Peritonitis," and if a collection of pus, no matter how large, is walled-off from the remaining peritoneum, it is called "Circumscribed Peritonitis" or simply "Abscess." This distinction is necessary, because the treatment varies with the different forms. Doctor Torek has been interested in "diffuse suppurative peritonitis" since 1902 and published his first eighteen cases in the Medical Record, December 1, 1906, where each of the cases is described in detail.

All agree that in diffuse suppurative peritonitis the appendix and the pus must be removed and the peritoneum must not be damaged. To evaluate the mode of procedure, which differs in different hands, a consideration of the following observations may be of help. In a case that has lasted longer than a day or two, ample opening of the abdomen will, after the pus has run out, often reveal very fine fresh adhesions attaching one loop of intestine to another or to the parietal peritoneum. These are usually so fine that a mere touch will separate them and evacuate collections of pus which may be considerable in quantity and may be far distant from the appendix. Several such collections may be encountered in the same case. To any one who is familiar with this condition it must be evident that the Fowler posture cannot be effectual in causing the pus to gravitate into the pelvis and to flow out from there through a drain. Even before these fine adhesions have been established the pus will be prevented from running into the pelvis if the intestines are more or less distended. Likewise, the attempt at washing out the peritoneal cavity from a small appendix incision by the use of a long double-current metal tube, as recommended by Blake in 1904, will fail to accomplish its object, as only a small part of the peritoneal cavity will be washed in this way. These methods of procedure could be effectual only in very early cases.

Doctor Torek makes a median incision from pubis to two inches or more above the umbilicus. As the peritoneum is incised, the pus flows from both sides of the incision. In one case, a successful one, it spurted a foot high as the knife entered the peritoneum. The suction tube is used only under guidance of the eye, as any damage of the peritoneum by this instrument would lessen the chances of recovery. For the same reason the use of wipes, especially their energetic use, is to be discouraged. After the bulk of pus is eliminated, the appendix is quickly removed and the peritoneal cavity is thoroughly and systematically flushed with large amounts of saline poured from flasks. First the exposed intestines are rinsed, next the cæcum and right gutter, then the pelvis and finally the left gutter, until the water flows out clear. The hand assists the cleansing by gentle to-and-fro motions. When fresh adhesions are encountered, they are separated, as pus will usually be found behind them. The large incision makes it possible to handle the peritoneum very gently during the cleansing process. Eventration, of course, is avoided, if possible, but a comparatively short eventration will be less hurtful to the congested peritoneum than extensive and often ineffectual stuffing with gauze pads.

The abdomen is then closed without drainage. The omission of drainage is a very important step in the management of these cases. Doctor Shipley has shown the inefficiency of drainage. It is impossible to drain the peritoneal cavity, and any attempt to do so will interfere with the reparative power of the peritoneum. Only in a few cases where, at the root of the appendix, the cæcum appeared to be threatened with necrosis, a drain was introduced through a separate opening to take care of that restricted area.

The closure of the abdomen is done by through-and-through sutures, not only because the saving of time in these cases is important, but also because the abdominal incision is infected and a separation of the different layers would spread the infection.

In the after-treatment no attempt is made to move the bowels for about four days, as the inflamed peritoneum requires rest. At that time a small rectal irrigation is permissible, the administration of a regular enema being reserved for the fifth or sixth day.

Doctor Shipley has referred to the adhesions caused by the presence of the drains. In this connection the experience in one of Doctor Torek's cases is of interest. As the pain was most intense in the upper abdomen, the possibility of perforation of other organs had to be considered, and the incision turned out to be the longest in the series, from ensiform cartilage to pubis. Owing to enormous distention the gut had to be opened in three places to allow gas and fluid contents to escape. Sixteen months after the operation the patient returned to be operated for a large post-operative hernia, at which occasion the peritoneum was found almost entirely free from adhesions, a condition probably due largely to the omission of drainage.

Of these eighteen cases all that had been operated in the first seventy hours of their peritonitis were saved. One patient operated at the end of the third day and two operated on the fourth day died. Some cases operated on the fourth day recovered. Of the three that died, one was moribund when operated, another was so badly septic that the operation did not even temporarily halt the sepsis.

On December 5, 1908, Doctor Torek reported a second series of eighteen cases in the New York Medical Journal, in which the mortality was exactly the same, $16 \frac{2}{3}$ per cent. The cases were not selected, operation being refused in only one case, that of a patient who was moribund and died unoperated upon a few hours after admission. Operations subsequent to these thirty-six cases had a lower mortality, but they have not been tabulated.

DR. J. SHELTON HORSLEY (Richmond, Va.) said that he was not for a moment advocating promiscuous appendectomies because of obliterative appendicitis. It is extremely difficult, if not almost impossible, to make even a probable diagnosis of obliterative appendicitis before the abdomen is opened. There may, however, be some cases in which this diagnosis may be suggested by the symptoms and physical signs which should be thoroughly studied.

Any one who carefully observes both grossly and microscopically the obliterated appendices he removes, can hardly make any other conclusion than that the diseased process is a chronic inflammatory one.

In regard to drainage, it is too often considered solely mechanical. It is partly that, but it is largely biological. In an appendicular abscess one puts the drain down into the abdomen for the pus to run up-hill, and expects the patient to get well. The patient usually does get well. But up-hill drainage with pus in the thigh or in the pleural cavity is usually not so successful, because in regions of this kind with a very poor lymphatic supply the drainage should be gravity drainage from the lowest point. The abdominal cavity is enormously supplied with lymphatics and with lymph. The drain one places in the abdomen causes a reaction that induces the lymphatics to pour out fluid toward the drain in an effort to expel the drain as a foreign body. In this way, the large amount of lymph that is diverted from the normal circulation and poured out along the drain tends to wash out the septic material.

CLOSING VERY LARGE HERNIAL OPENINGS

BY WILLIAM EDWARD GALLIE, M.D.

OF TORONTO, CANADA

AT THE meeting of the American Surgical Association held in 1922 a method of treatment for large ventral and inguinal hernias was described which involved the repair of the opening with autogenous sutures made from fascia lata.

Experience with this method extending over a period of ten years has been quite satisfactory and there is no question that it has greatly reduced the incidence of recurrence and widened the field in which operation is indicated.

There are some cases, however, in which the hernial ring is so large that no method of suture can adequately close the opening. There are others in which, while it is possible to draw the edges of the opening together by tight lacing of the suture, this can be done only with such an increase of the intra-abdominal pressure as to seriously endanger the life of the patient. In our earlier cases we tried to overcome this difficulty by simply filling the opening with a filigree of fascial sutures, much as one would darn a sock. In most cases this has proved successful but unfortunately, in a certain number, recurrences have developed which subsequent operation has shown to be due to protrusion through chinks between the sutures. We have accordingly been on the lookout for a more certain method of closure.

This has been found in a combination of the patch transplant with the living suture. It will be remembered that the defect in the patch transplant was that it could not be depended upon to heal strongly into the opening. There was no doubt that it could be expected to live but there was great doubt in regard to the strength of the scar and areolar tissue that joined its edges to the hernial ring. This uncertainty can be overcome by using as a patch transplant a sheet of fascia lata whose ends have been split into quarter-inch strips so that it resembles the old-fashioned many-tailed abdominal bandage. When the strips have been threaded on needles they are passed through the thick margins of the ring and those of one side of the opening are tied to those of the other, bringing the edges as closely together as seems desirable. In this way a strong aponeurotic structure, free of chinks and other weak spots, is securely fastened into the defect and may be depended upon to close the opening permanently.

The method is particularly applicable to large ventral hernias and most frequently to hernias resulting from suppuration following operations on the gall-bladder and stomach. It is useful also in cases of large direct inguinal hernias, particularly those in which the abdominal wall is feeble and in which several unsuccessful operations had previously been performed.

In the case of the ventral hernias a few special points in technic should

be observed. In preparing the hernial opening for the closure no attempt is made to separate the various layers from one another as this definitely weakens the wall. The peritoneum is pushed back from the edge of the opening for half an inch or more so that the needle may be passed from within outward

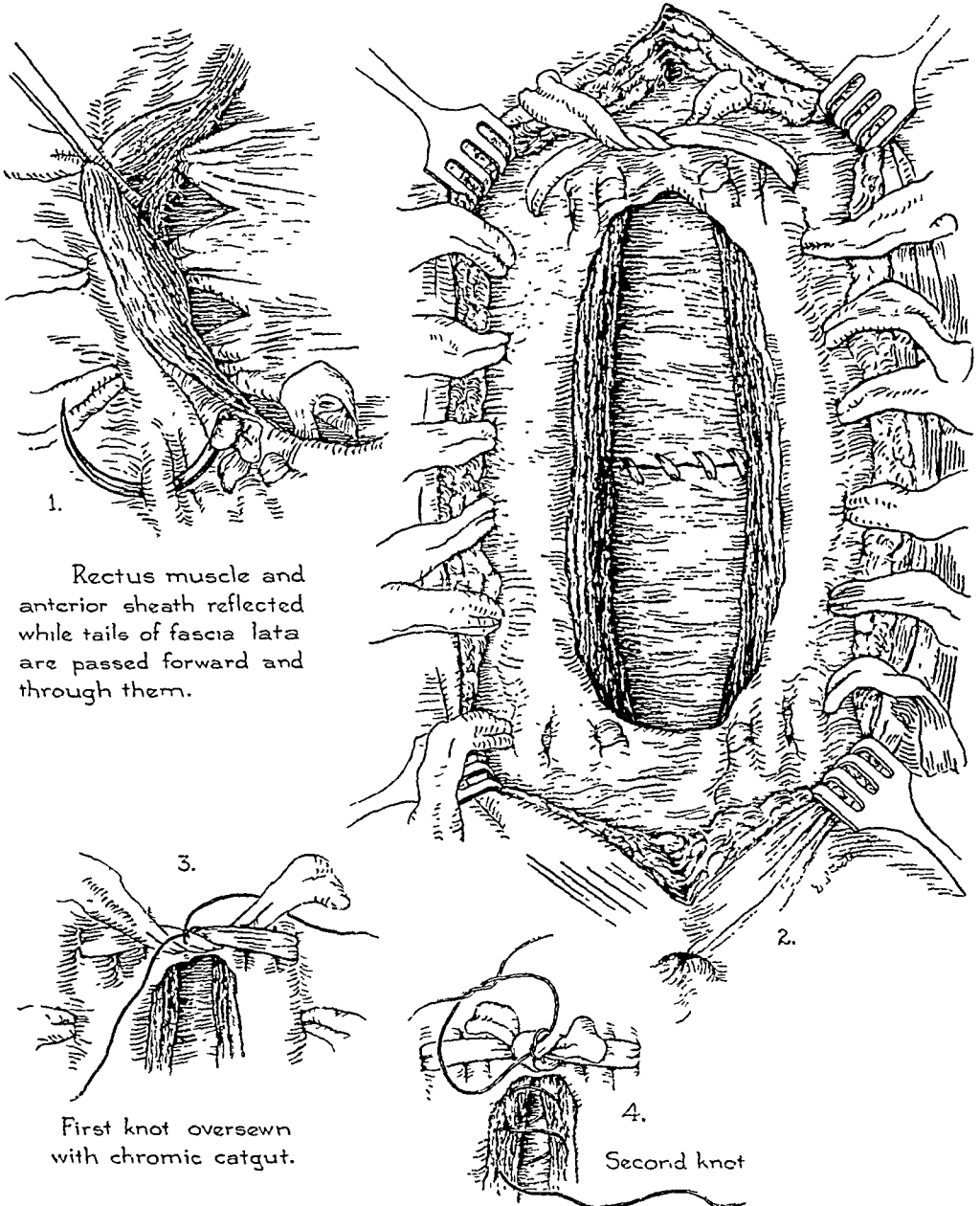


DIAGRAM 1.—Wide ventral hernial opening closed by two sheets of fascia lata placed edge to edge. The inserts show the method of passing the tails through the edge of the hernia ring, and the method of tying and oversewing the tails.

through the edge of the ring without entering the abdominal cavity. If the hernial opening is longer than three and one-half inches it will be necessary to cut two patches from the fascia lata which will be laid side by side across the opening. As a rule, two patches of fascia, five inches by three and one-half inches, can be obtained from the lateral aspect of a single thigh. The

CLOSING LARGE HERNIAL OPENINGS

ends of the patches are then split into strips about one-quarter of an inch wide and by means of a fascia needle passed through the edges of the ring as shown in Diagram 1. If a second patch is needed it is laid edge to edge with the first and the two are sewn together with a fine strip of fascia lata threaded on a needle. At the ends of the opening, special precaution is taken to weave the tails into the edge of the ring so as to prevent a protrusion over the end of the fascial sheet. When all the tails have been drawn through the abdominal wall they are tied together, each to its fellow of the opposite side, and the edges of the opening drawn together as closely as seems safe. If they can be brought into contact without too much tension, so much the better, but, if they cannot, the surgeon may rest assured that the deep side of the defect in the abdominal wall has been permanently closed off. Often it is possible, where the deep portion of the opening cannot be drawn together, to close the anterior rectus sheath with catgut or a suture of fascia and this shuts off the sheets of fascia from view and seems to be an advantage. Care should be taken to oversew the knots in the tails of fascia with catgut as these have a strong tendency to slip and untie when strain is put upon them.

In inguinal hernia the need for the many-tailed fascial sheet is not great. Occasionally, however, cases appear in which the abdominal defect is very large or in which the abdominal muscles and Poupart's ligament seem too weak to withstand strain after any form of suture, and for such cases this method is useful.

The details of the operation are similar to those already described and are well illustrated in Diagram 2. The sheet of fascia which is obtained from the thigh is $2\frac{1}{2}$ to 3 inches wide and $3\frac{1}{2}$ to 4 inches long. Its two ends are split into quarter-inch tails which, by means of a fascia needle, are passed through the recurved edge of Poupart's ligament on one side and through the internal oblique muscle and its aponeurosis on the other. When the tails are pulled up tight the fascial sheet completely occupies the space in the posterior wall of the inguinal canal normally occupied by fascia transversalis and presents an impenetrable barrier to the protrusion of a hernia. Precaution should be taken to weave the lower tails into Gimbernat's ligament in such a way as to prevent all possibility of a protrusion around the lower end of the sheet and at the upper end of the canal the edge of the fascial sheet should be placed deep to the internal oblique muscle beyond its origin from Poupart's ligament so that a protrusion around the outer edge of the sheet would be impossible. As a rule the sheet should extend beyond the normal position of the internal ring so that the cord must be allowed to enter the abdomen between two adjacent tails. The tails are now drawn taut and tied together and the knots are oversewn with catgut as shown in the diagram. The external oblique is then closed in the ordinary way.

In each of the operations in which we have used sheets of fascia to close large hernial defects variations in technic have occurred according to the difficulties encountered. It is unlikely that any surgeon will ever find two cases alike so that anything like a standardized technic is impossible. If the general principle, however, is adopted of shutting off the opening on its deep

side with a strong sheet of fascia which is fixed into the borders of the defect by tails cut in the end of the sheet and if care is taken to weave the tails into the ends of the opening so that a protrusion cannot occur around the margin of the fascia, one may rest assured that the risk of recurrence will be small.



DIAGRAM 2.—Repair of posterior wall of inguinal canal by many-tailed fascial sheet.

The disability resulting from the removal of sheets of fascia from the thigh is fortunately very slight. Occasionally, patients complain of a slight sense of weakness, but as a rule they do not. Under any circumstances, the disability is negligible when considered in relation to the relief the patient has experienced in the closure of his hernia.

ABDOMINAL INCISIONS AND THEIR CLOSURE

BY ARTHUR DEAN BEVAN, M.D.

OF CHICAGO, ILL.

ONE of the most important subjects in abdominal surgery is that of abdominal incisions and their closure. This subject has been studied by many surgeons and in a general way has been fairly well standardized. There are certain anatomical and surgical principles which govern the character of abdominal incisions.

First.—The incision should give adequate exposure of the field of operation.

Second.—It should injure as little as possible the nerve and blood supply and the function of the muscles of the abdominal wall.

Third.—It should be so planned that primary firm union can be secured which will prevent the opening up of the wound or the later development of a post-operative hernia.

There are certain abdominal incisions which quite fully live up to these requirements and which are generally adopted. These incisions answer well in the great majority of abdominal operations.

In Fig. 1 three incisions are shown in the median line: One between the ensiform and the umbilicus; one between the umbilicus and the symphysis; and a third which has its centre at the umbilicus and a little to the left so as to avoid the round ligament. These incisions are so planned that they are in an avascular territory. They do no injury to the nerve supply and they in no way impair the function of the abdominal muscles. In this same figure you will notice the oblique muscle-splitting incision of McBurney and McArthur used for operations on the appendix and colon and somewhat modified for stone in the central portion of the ureter. I shall later call your attention to an extension and enlargement of this incision which answers well in resection of the right colon and some operations involving the retroperitoneal space. On the left side this same oblique muscle-splitting incision can be used for operations on the lower end of the descending colon, the sigmoid and the left ureter and the retroperitoneal space.

In Fig. 2 I have presented a view of the oblique kidney incision which is so planned that it runs parallel with the nerve supply and which can easily be extended forward so as to expose widely the retroperitoneal space where it is necessary to remove huge kidney tumors or to remove a stone from the lower end of the ureter. This incision can be greatly enlarged by forcibly stretching it apart with the two hands; in doing this the twelfth rib can be fractured at its neck or the ligaments binding the rib to the transverse process ruptured, giving much more room. I shall come back to this incision again in the discussion of the surgery of the retroperitoneal space.

In order to refresh your mind for the moment in regard to the anatomy of

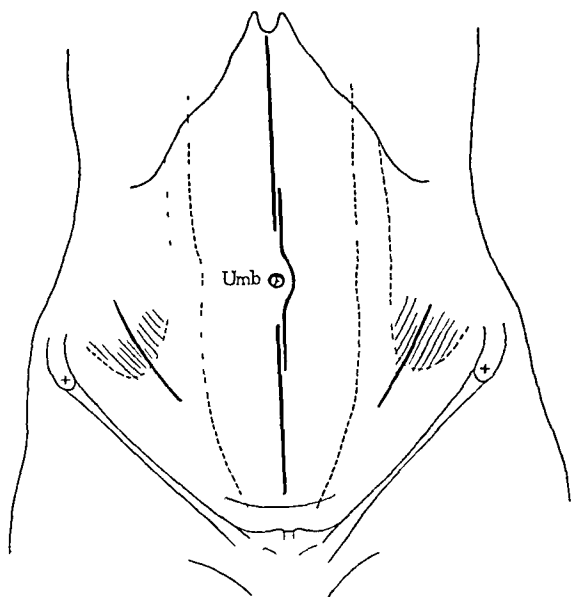


FIG 1.

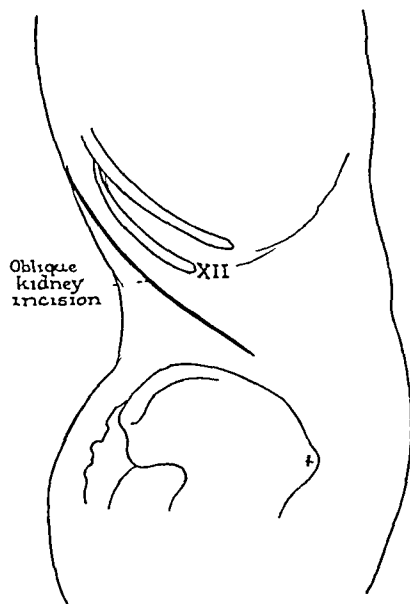


FIG. 2.

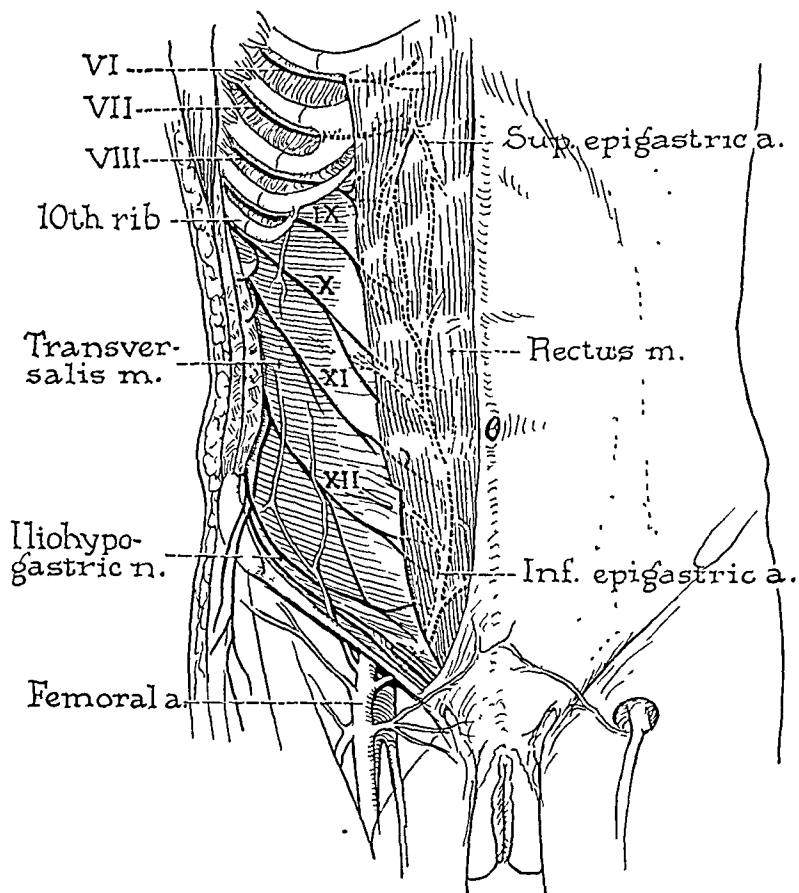


FIG 3

ABDOMINAL INCISIONS AND THEIR CLOSURE

the abdominal wall, I show you in Fig. 3 the blood supply and the nerve supply of the abdomen, and in Fig. 4 the muscles of the abdominal wall, and in Fig. 5 the rectus muscle and the arrangement of its anterior and posterior sheaths above and below the linea semicircularis, the semicircular fold of

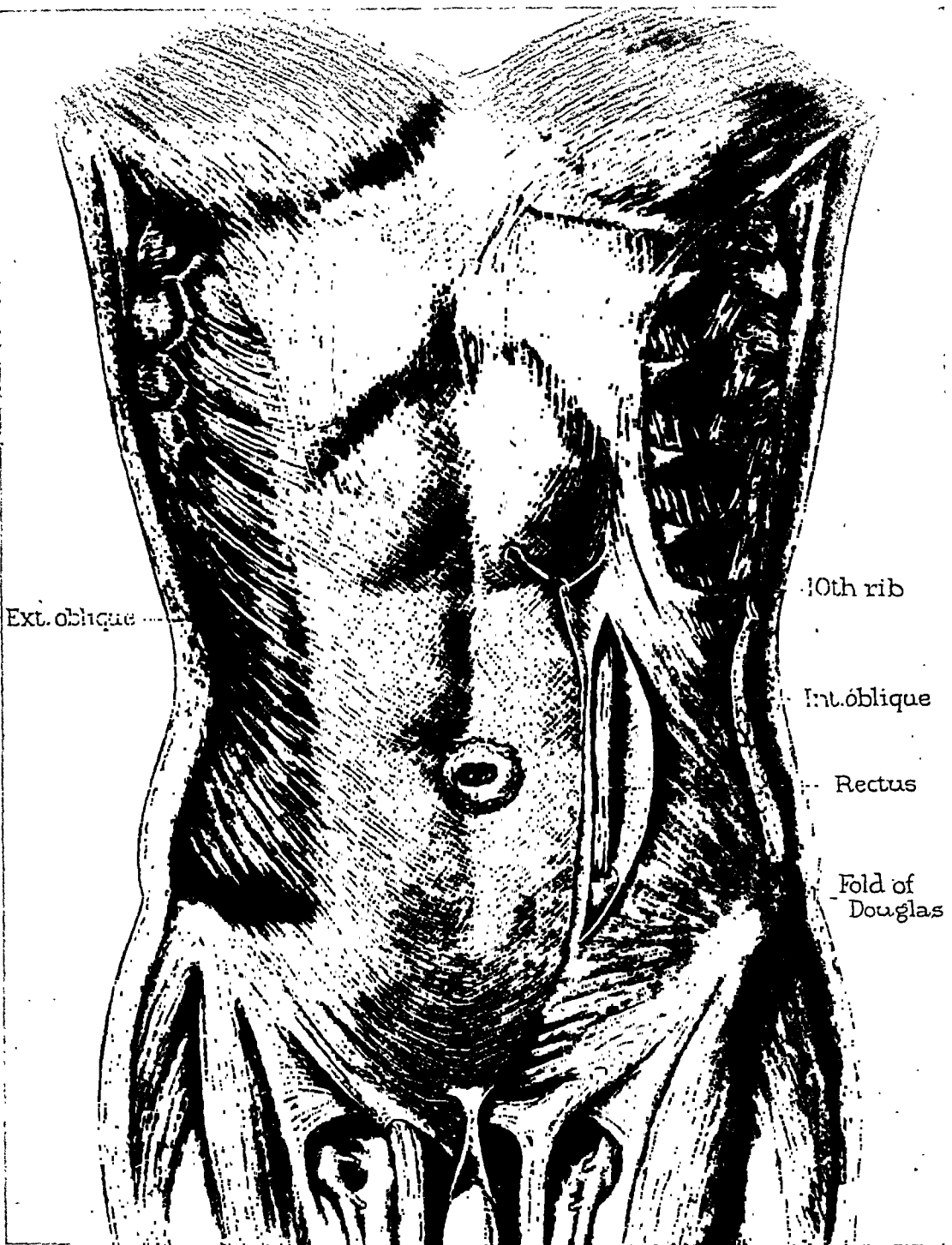


FIG. 4.

Douglas. With these charts of the abdominal wall in mind let us now consider some of the muscle-splitting incisions which have great value in special fields.

First, let me again refer to the McBurney and McArthur muscle-splitting incision for the surgery of the appendix. This was first published by

McBurney. L. L. McArthur, however, had independently developed the same incision and had employed it in a large number of cases and had found that

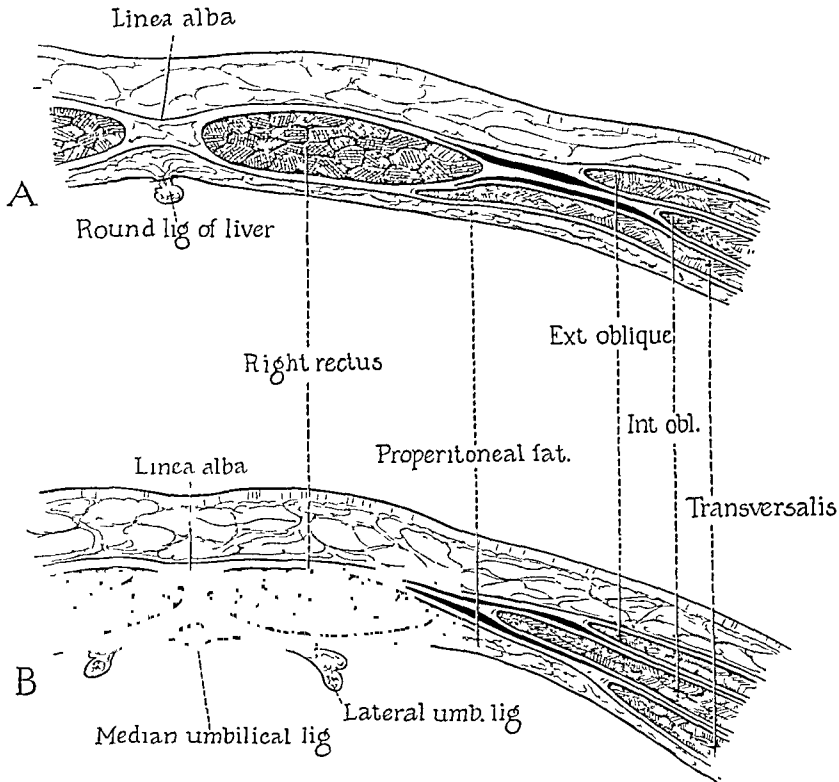


FIG. 5.

it was of special value in the suppurating cases. McBurney at first recommended it in non-suppurating cases. This is so well known that it is not necessary for me to describe it in detail. I have used the incision since 1895

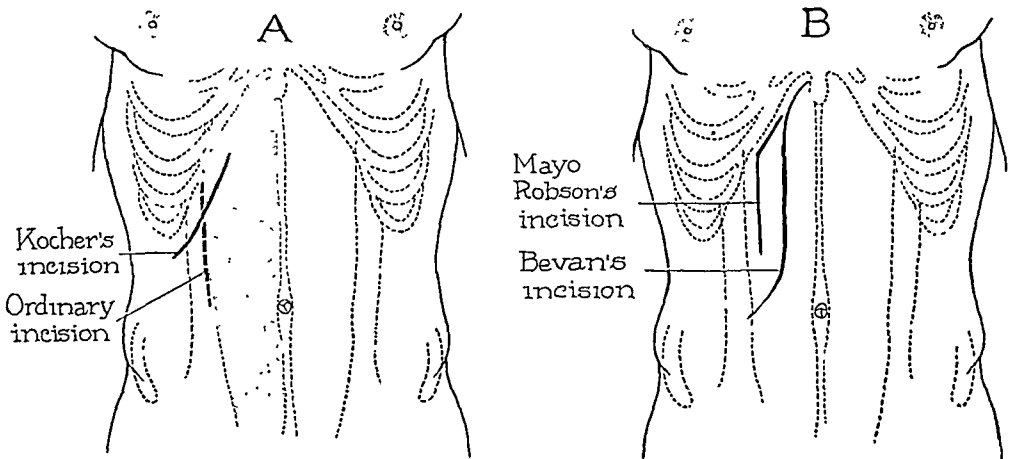


FIG. 6.

and believe that it is planned on sound anatomical and surgical lines and is of great value.

While I was professor of anatomy at Rush in 1897 and attending surgeon

ABDOMINAL INCISIONS AND THEIR CLOSURE

to the Presbyterian Hospital, and much interested in the surgery of the bile tracts, I made a number of dissections to determine the best surgical approach to the gall-bladder and bile ducts, and developed an S-shaped incision at the outer border of the rectus which gave admirable exposure and injured the nerve supply much less than did the Kocher incision or the long vertical incisions at the outer border of the rectus which were then employed. (See

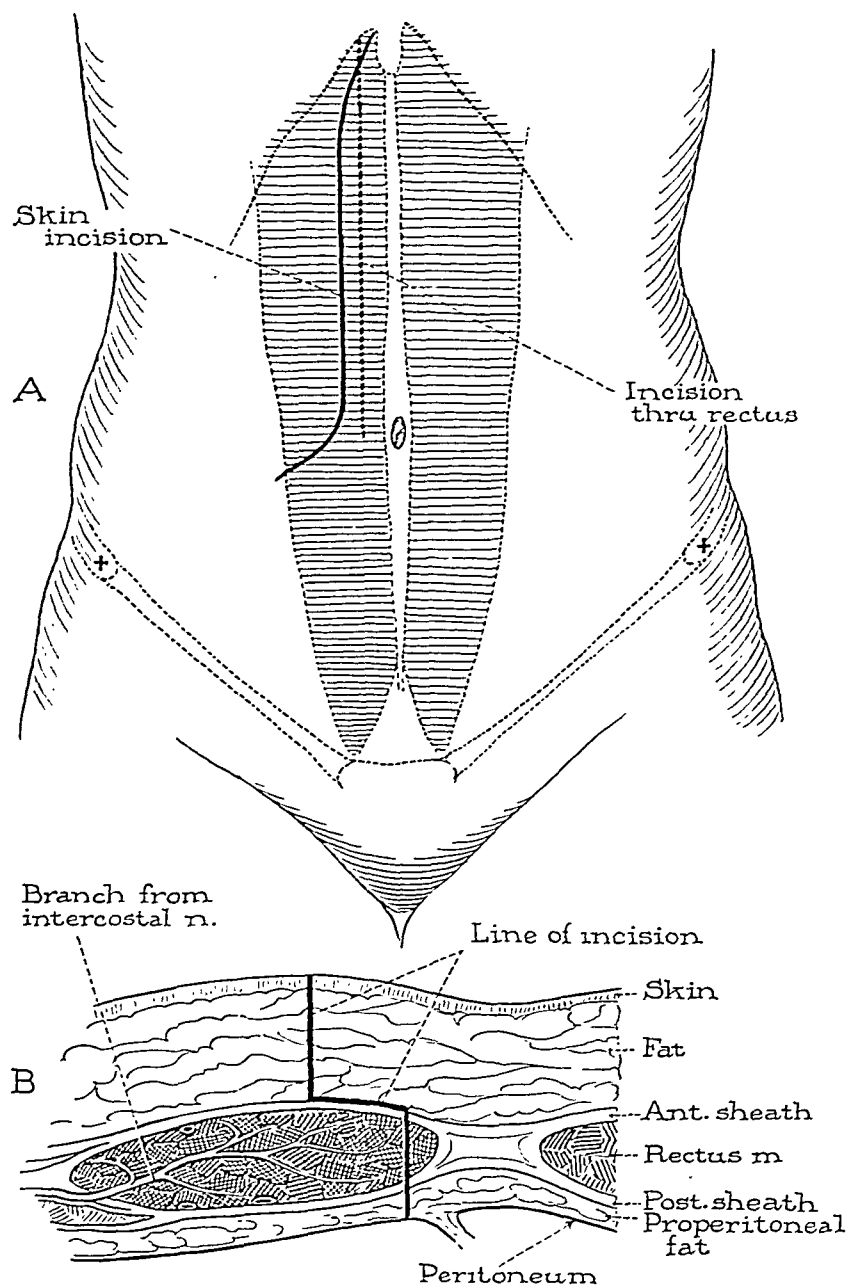


FIG. 7.

Fig. 6A.) I have reproduced the two incisions which were most frequently used up to 1900 for operations on the gall-bladder and bile tracts, namely: the ordinary incision at the outer border of the rectus or in the outer part of the rectus which was most frequently employed at that time, and the Kocher incision which was parallel to the costal arch. I used my incision as originally planned only for a very short time and then modified it at the suggestion of

Robert Weir, by moving the vertical part of the incision inward for two inches so that it was over the middle of the rectus. This incision, which we have used for about thirty years, is shown in Fig. 6B. This plate also shows the Mayo-Robson incision.

In making this incision, at first we split the rectus about the centre; very shortly, however, we split it so as to leave two-thirds of the muscle to the

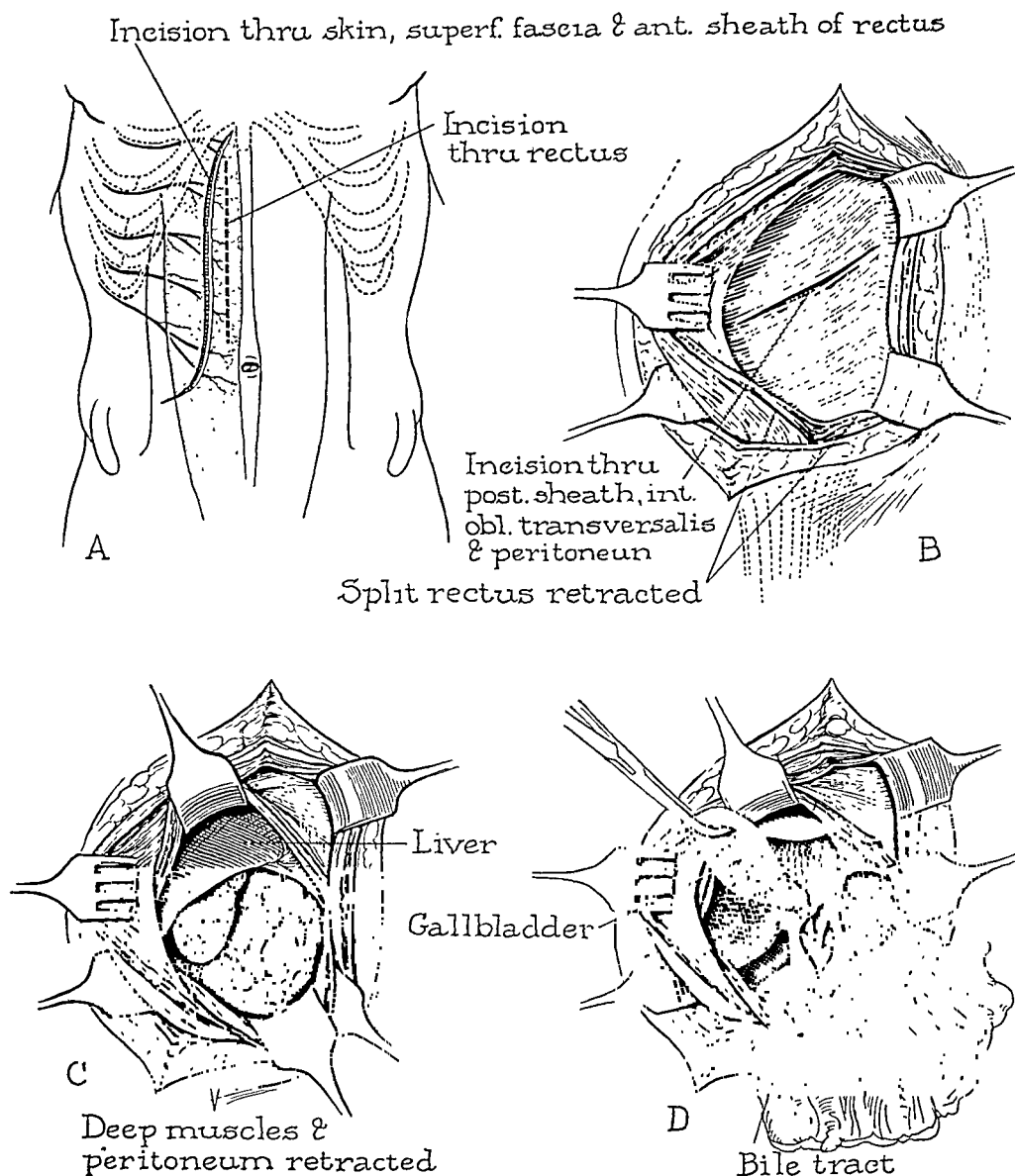


FIG. 8.

outer side and then later so as to leave three-fourths to the outer side, and, finally, a mere ribbon of the rectus one-third of an inch wide was left internal to the incision and for the special purpose of making easier the repair and suture of the posterior sheath. (See Fig. 7.) We have since then experimented with this bile-tract incision in a number of ways. We sometimes

ABDOMINAL INCISIONS AND THEIR CLOSURE

turn the entire rectus to the outer side, making a paramedian incision of it, such as Moynihan uses. We have in a number of cases using the same skin incision adopted a suggestion made by McArthur of splitting the internal oblique and the transversalis parallel with their fibres and at about right angles to the vertical part of our incision. This makes a muscle-splitting incision which gives very good exposure and gives wonderful insurance

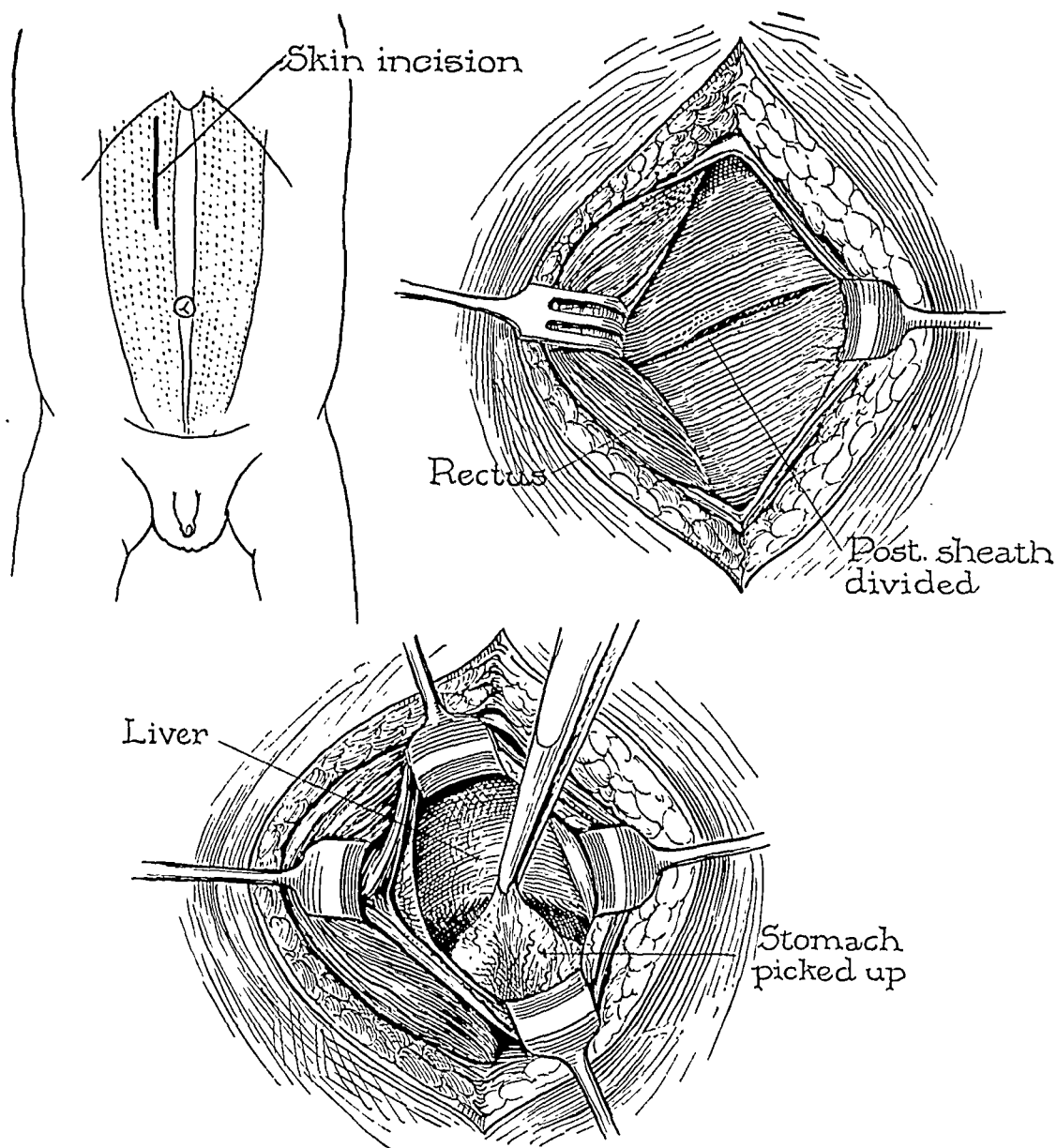


FIG. 9.

against post-operative hernia. This muscle-splitting incision answers very well in cholecystostomies and uncomplicated cholecystectomies and it makes the best possible incision for congenital pyloric stenosis in infants, especially where local anæsthesia is used. Fig. 8 shows the muscle-splitting incision for gall-bladder and bile-tract operations, and Fig. 9 for congenital pyloric stenosis.

Recently, we have been trying out another form of incision for the surgery of the bile tracts which in many ways is anatomically and physi-

ologically, from the standpoint of producing no injury to the blood supply and nerve supply and muscle tissue, and from the surgical standpoint of good exposure of the operative field and of closure, probably the best incision we

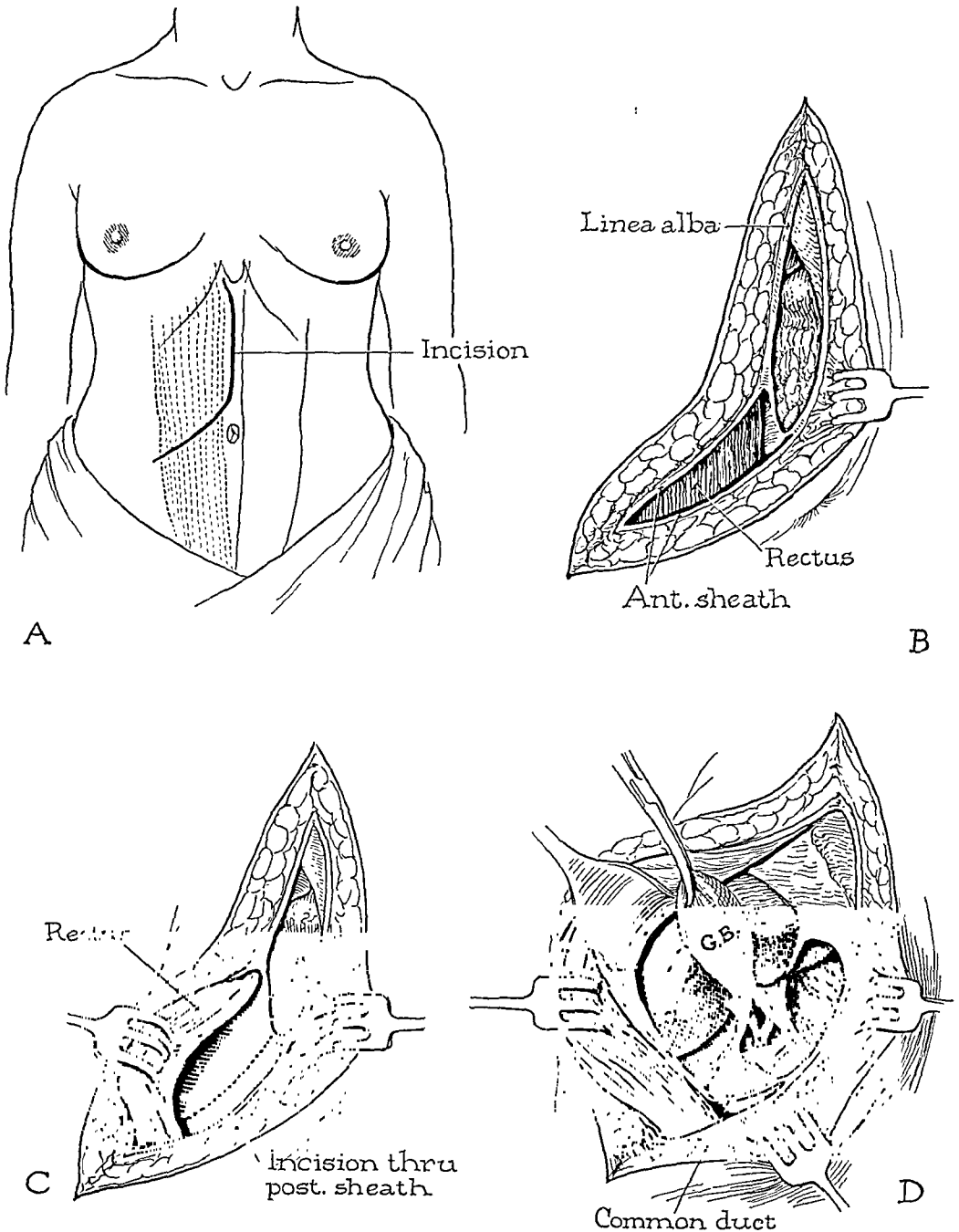


FIG. 10.

have experimented with. We have used it in but a limited number of cases. So far the results are most satisfactory. The incision is shown in Fig. 10. It begins in the angle between the ensiform and the costal arch a little to the right of the median line, passes downward in the linea alba to about an inch

ABDOMINAL INCISIONS AND THEIR CLOSURE

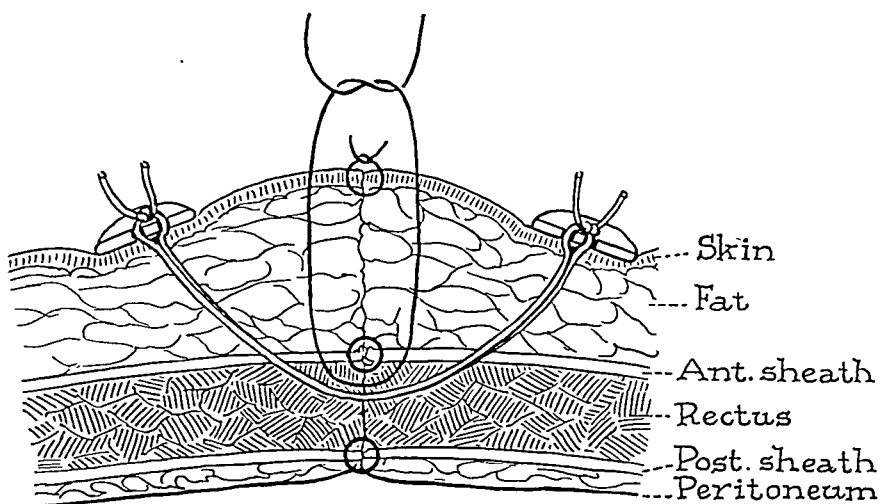


FIG. 11.

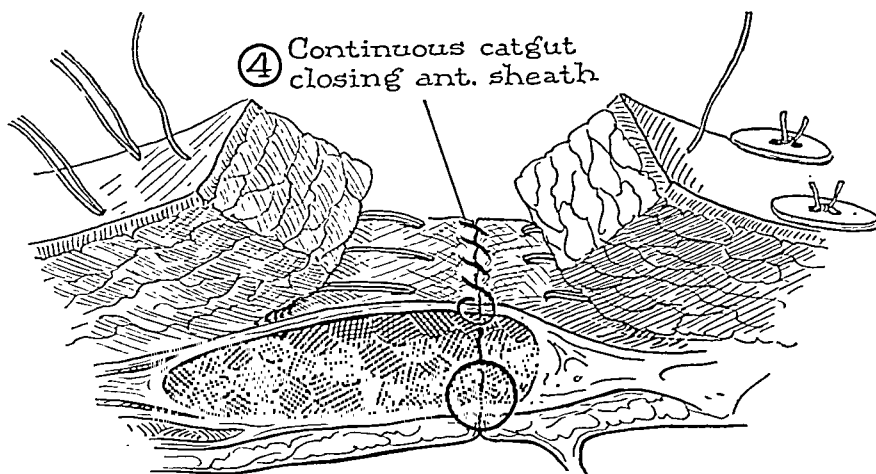
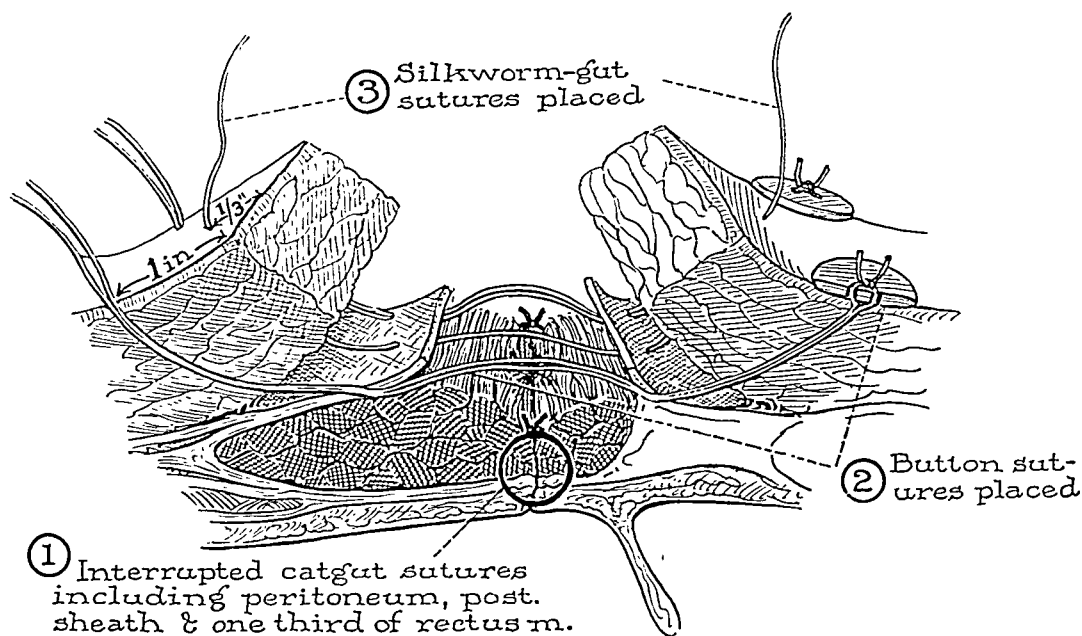


FIG. 12.

above the umbilicus; here it turns outward sharply three or four inches; we divide skin, superficial fascia, the linea alba and the outer sheath of the rectus in the lower curved portion of the incision. This exposes the rectus muscle which is pulled outward with a blunt hook retractor so as to expose the

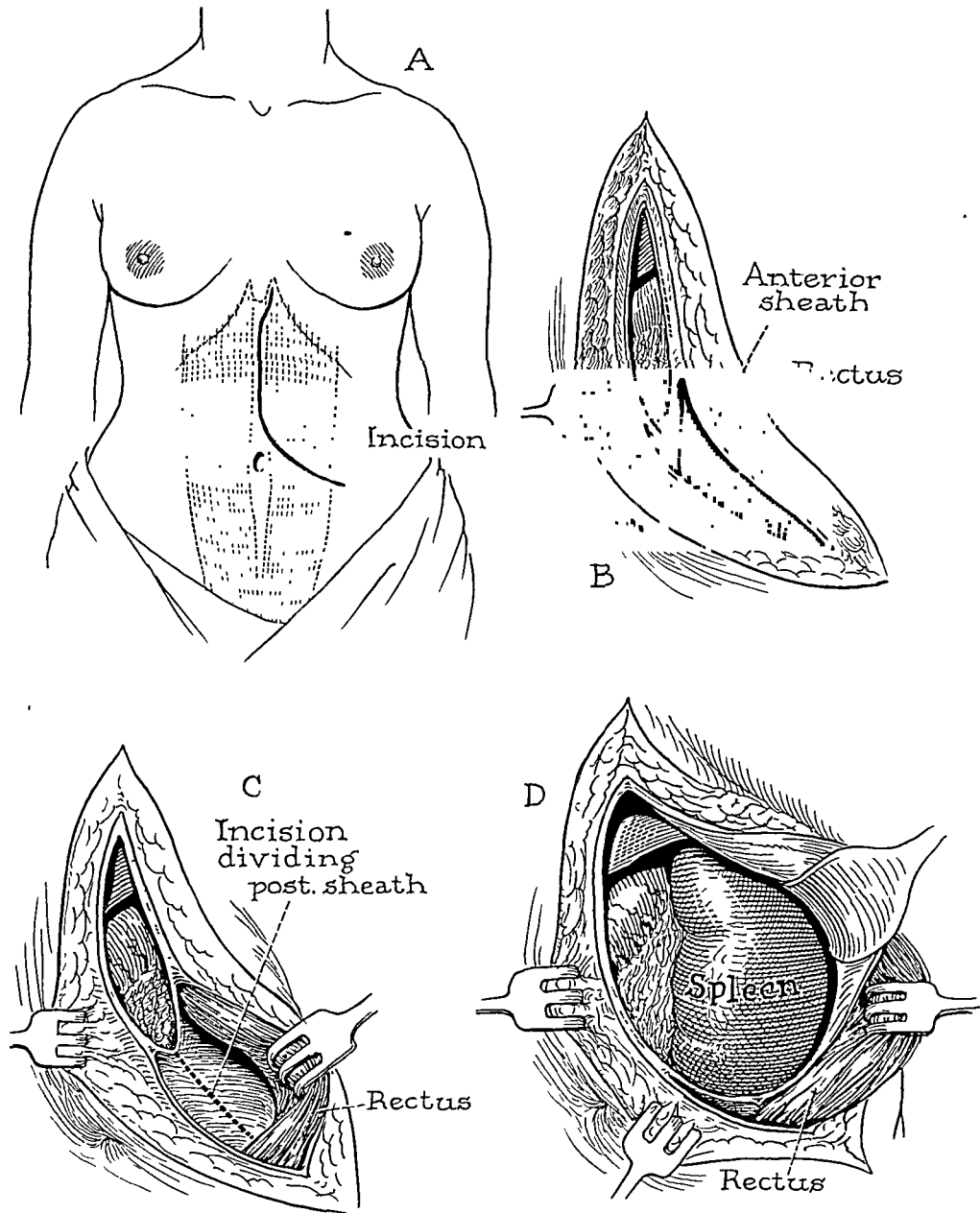


FIG. 13.

posterior sheath of the rectus. This is divided transversely to the extent of three or four inches; this enables us to turn out a huge trap door of the abdominal wall forming the right upper quadrant of the abdomen. In closing, the peritoneum, linea alba and posterior sheath of the rectus in the curved part of the incision are first closed with catgut, the rectus is allowed

ABDOMINAL INCISIONS AND THEIR CLOSURE

to return to its normal position and then the anterior sheath of the rectus is closed with catgut and the incision in the linea alba closed in the usual way.

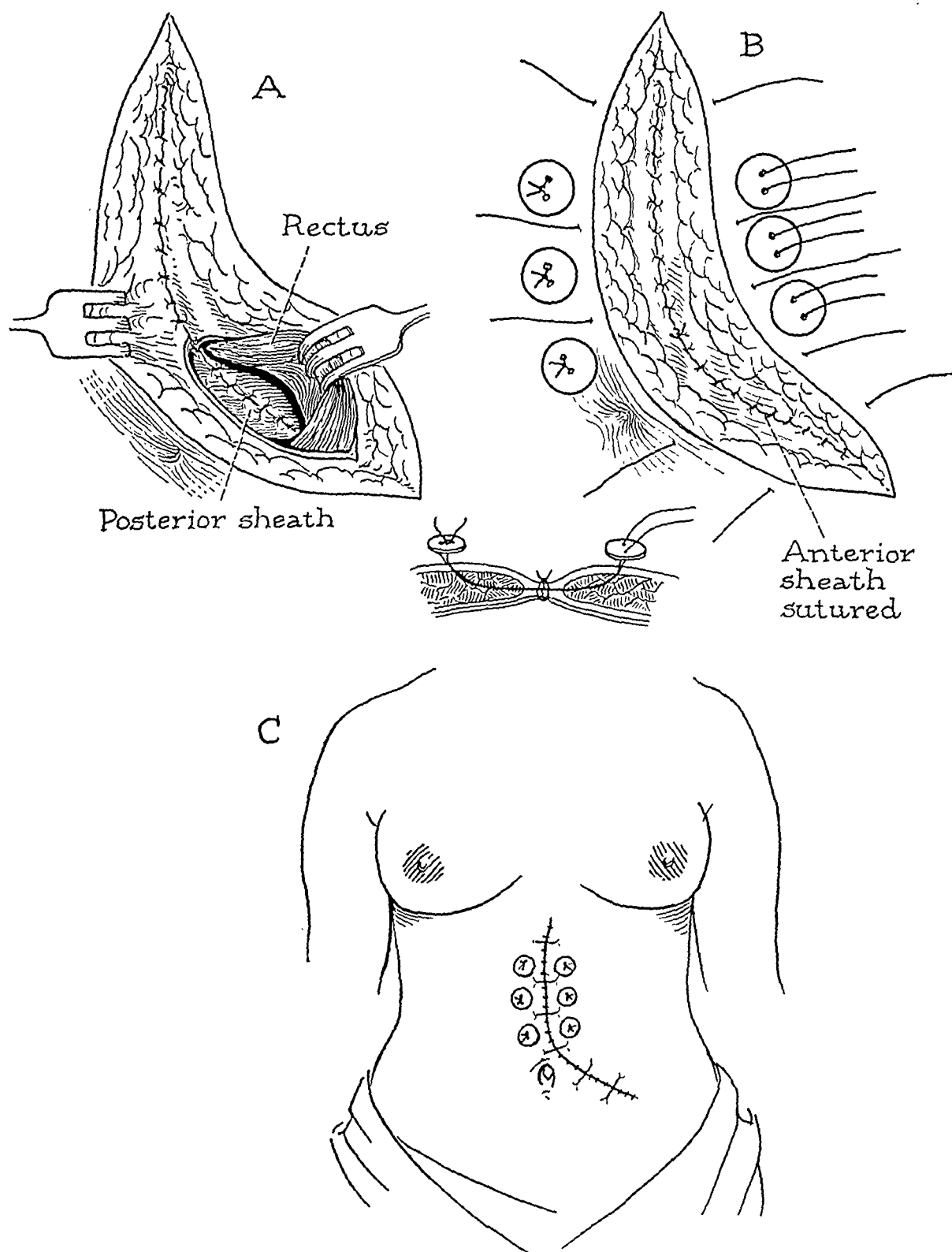


FIG. 14.

I show this closure in the spleen incision. Before closing the incision, a good-sized sharp trocar and cannula are passed from within outward through the outer part of the rectus on a level with the cystic duct and a

moderate-sized French catheter is drawn through the cannula and left in the abdominal cavity for drainage.

I might here describe the plan of closure of these abdominal incisions. (See Figs. 11 and 12.) This is more or less diagrammatic. These plates show, however, very well, the suture method which we employ. First, the peritoneum and posterior sheath of the rectus are closed with rather fine catgut. Then about every two inches a tension-button suture is passed through the skin, superficial fascia and anterior sheath of the rectus. These buttons are about seven-eighths of an inch in diameter and are the pearl buttons of commerce made from mussel shells. They are easily sterilized and kept in alcohol. A large curved needle is threaded with two pieces of silkworm gut; these are passed through two eyes of the button and tied. These sutures are passed about one and one-half inches from the line of the incision. We usually use from three to four of these tension-button sutures; between

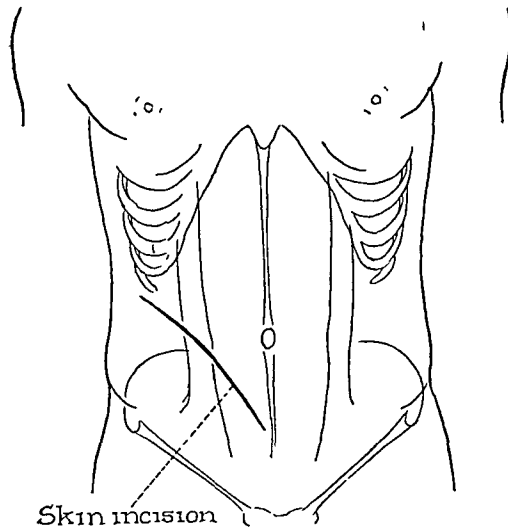


FIG. 15.

the tension-button sutures and above and below these we use a single strand of silkworm gut which is introduced one-fourth of an inch from the line of the incision and this passes, as shown in the plates, through the skin, superficial fascia and the anterior sheath of the rectus. The anterior sheath of the rectus is now closed with catgut and the skin with black silk. Metal clamps should not be used to close the skin in abdominal incisions because in some cases where the wound has opened up some of the clamps have been lost in the eviscerated intestines and omentum and have even produced intestinal

perforation and death. We have used these tension-button sutures for many years. Their use has practically eliminated the opening up and evisceration in our abdominal wounds.

The last incision which I have just described for exposure of the bile tracts was first worked out on the left side for exposure of the spleen, for abdominal approach to diaphragmatic hernia and resection of the splenic flexure of the colon. This spleen incision which we are now advocating has been a matter of evolution covering a number of years. We first used the S-shaped incision on the left side which we had developed for the exposure of the bile tracts. Then later we experimented with an incision beginning in the median line and curving outward above or below the umbilicus, depending on the size of the splenic mass, divided the rectus and its anterior and posterior sheath; this gave us wide exposure. Later we found that the division of the rectus muscle was seldom necessary so we now simply divide both the anterior and the posterior sheaths, retract the rectus and obtain in

this way very excellent exposure. (See Fig. 13.) It is true that in many cases splenectomy can be well done with a mid-line incision, if necessary, extending well below the umbilicus. The division of the anterior and posterior sheaths of the rectus in difficult cases, however, is of great help. This incision answers admirably for operations on diaphragmatic hernia at the œsophageal opening and also for operations on the splenic flexure. Fig. 14 shows the method of closure.

I now desire to describe somewhat in detail the large extended muscle-splitting incisions which we are employing on both the right and left sides; on the right side especially for resecting the right colon and on the left side

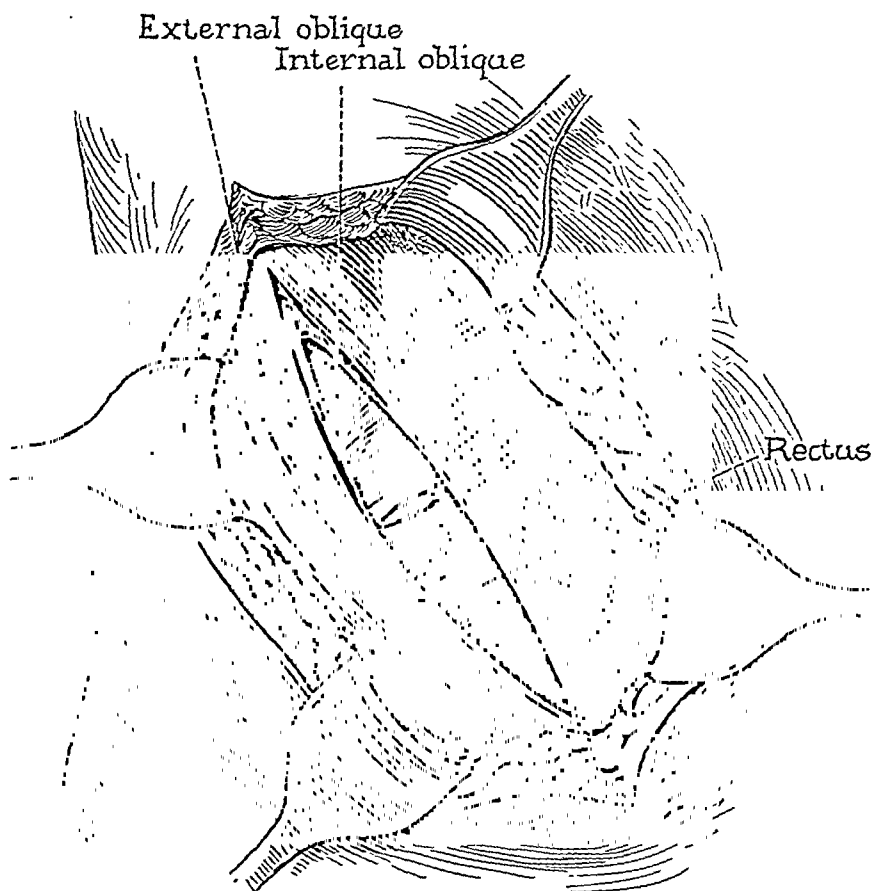


FIG. 16.

for resecting the sigmoid. I shall now describe this large extended incision on the right side. (See Fig. 15.) The incision begins at a point below the tenth rib and runs parallel with the fibres of the external oblique muscle downward and inward, almost to the mid-line. This incision divides the skin, superficial fascia and the external oblique parallel with its fibres. The external oblique is now reflexed, exposing the internal oblique widely; the internal oblique and the transversalis are now divided parallel to their fibres as in the usual McBurney and McArthur incision, and the subperitoneal fat and peritoneum exposed. (Fig. 16.) We now with our two hands, as shown in Fig. 17A, stretch the opening in the internal oblique and transversalis widely and if necessary tear these fibres which enter into the formation of the anterior sheath of the rectus almost to the mid-line. In this

way a very large opening is obtained without any injury to the nerves or blood supply or the muscles of the abdominal wall. Fig. 17B is sketched from one of our cases of resection of the cæcum and ascending colon and hepatic flexure for carcinoma where this incision gave excellent exposure. On the left side this enlarged and extended muscle-splitting incision gives adequate exposure for operations on the lower half of the descending colon and the sigmoid flexure. It does not answer well for the exposure of the splenic flexure. In describing these enlarged and extended muscle-splitting incisions I desire to call attention to the fact that in difficult and complicated operations for appendicitis the usual McBurney incision can be enlarged and stretched in the same way to give very wide exposure. Both Robert Weir and Harrington suggested this years ago.

I desire to describe the method that has been developed in our clinic of handling the cases of opening up of an abdominal incision with evisceration. It was in these difficult cases that we began some years ago to use the large tension-button sutures. In the *Ergebnisse der Chirurgie und Orthopädie*, vol. xxv, Sokolov of Leningrad presents this subject very fully. He has collected 723 cases from the literature with a mortality of about 33 per cent.

In Fig. 18A we have sketched one of these cases of the opening up of the abdominal wound at the end of twelve days with some omentum and coils of small intestines exposed. An immediate resuture of the wound should be made in the following way: The patient is sent to the operating room; the omentum and coils of intestines covered with a moist abdominal pad. The field of operation is sterilized with iodine. The edges of the incision are infiltrated with $\frac{1}{2}$ per cent. of novocaine solution with 1-200,000 adrenalin; large tension-button sutures are now placed about one and one-half inches from the line of the incision and one and one-half inches apart. The moist abdominal pad is now removed and the eviscerated omentum and intestines held down by a flat metal retractor. (See Fig. 18B.) Beginning at one end of the incision the button-tension sutures are first drawn tightly together and tied. As the sutures are tied the flat metal is gradually withdrawn. The wound is now dressed with moist boric gauze and held firmly in place by a scultetus bandage. This dressing should be changed each twenty-four hours; no attempt should be made to close the skin tightly with skin sutures as it is desirable to obtain a certain amount of drainage between the tension-button sutures. It is as a rule not wise to use any gauze tampon or rubber drainage in these cases and it is not wise to attempt to sterilize the eviscerated abdominal contents, and it is as a rule a mistake to use a general anæsthetic. Following this simple method most of our cases have gone on to a recovery.

I desire finally to discuss the oblique incision for the exposure of the kidney and ureter and the structures in the retroperitoneal space. This field has recently been very fully covered in an article by Fritz Härtel, of Berlin, in the *Ergebnisse der Chirurgie und Orthopädie*, entitled: On the Surgery of the Retroperitoneal Space and the Dorsal Peritoneum. I have, myself, been for some years interested in this field. Küttner, of Breslau, in the *Trans-*

ABDOMINAL INCISIONS AND THEIR CLOSURE

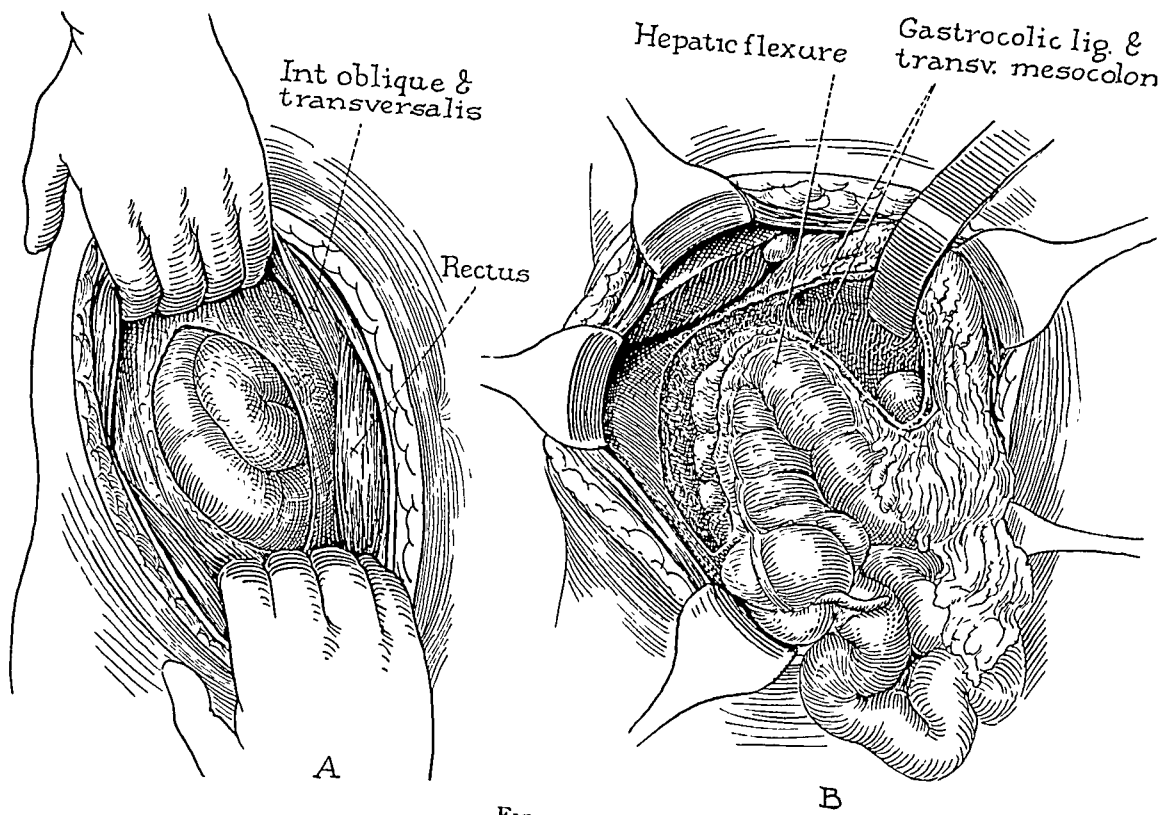


FIG. 17.

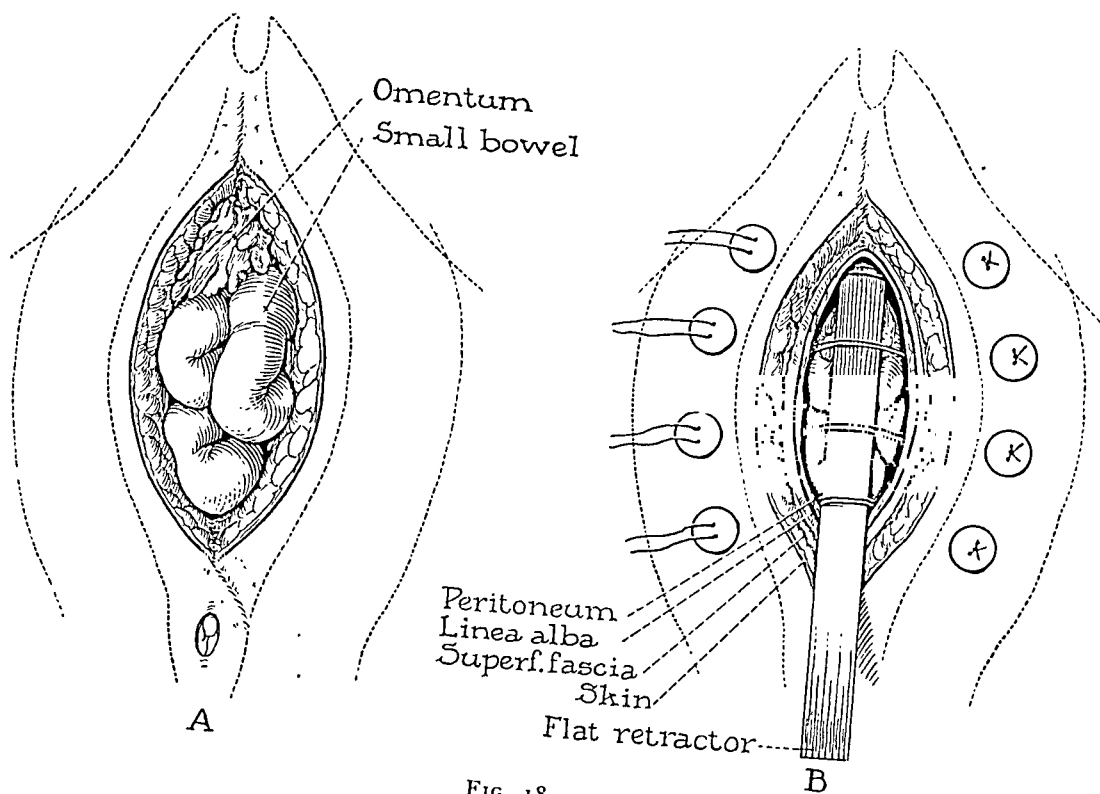


FIG. 18.

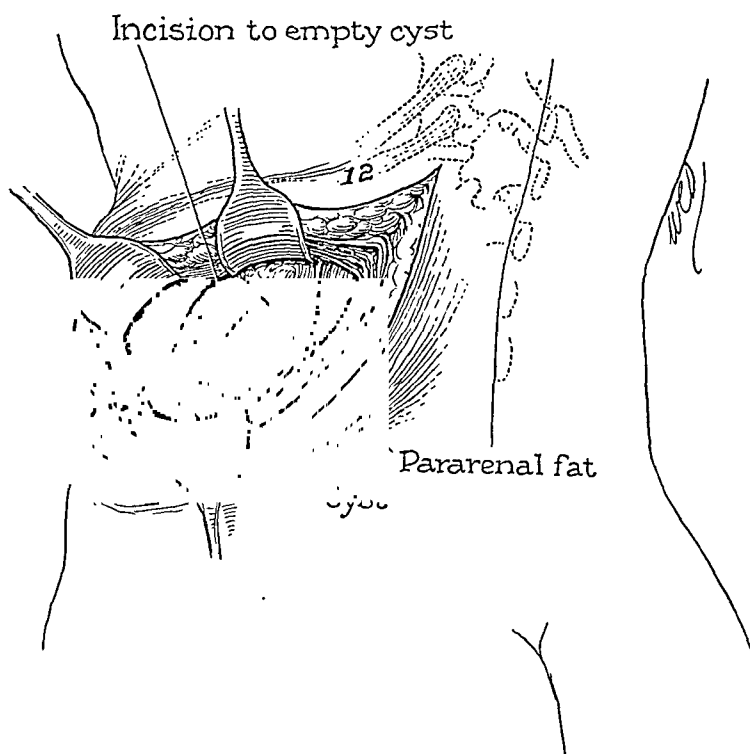


FIG. 19.

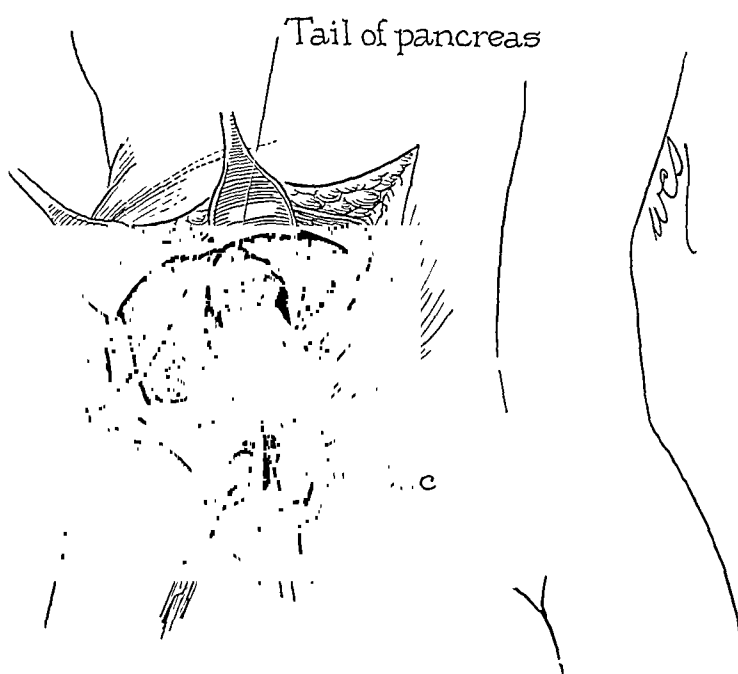


FIG. 20.

actions of the German Congress for Surgery last year, in discussing Härtel's paper, states that for years he has employed the retroperitoneal approach in many operations. He advocates it in some resections of the ascending and descending colon, in some splenectomies, in some pancreatic cysts, and in draining of certain pancreatic infections. I believe that the retroperitoneal approach has a wider field of usefulness than we have up to the present time realized. I have employed it in various types of retroperitoneal and subphrenic abscess, in resection of the ascending and descending colon, in lesions of the kidney and ureter, in various types of retroperitoneal tumors and in injuries of the duodenum. Härtel regards it as the best approach in splenectomy. I have recently employed it in removing a large cyst of the pancreas where I was surprised and delighted to find that it gave very satisfactory exposure and where the operation was completed without opening the general peritoneal cavity. (See Figs. 19 and 20.) I believe that we should cultivate more thoroughly the great possibilities of this retroperitoneal approach.

The making of abdominal incisions and their closure is a very fascinating study. It is by no means a closed chapter. I have in this brief paper attempted to present the results of the research in this field which we have carried on in our own clinic.

DISCUSSION.—DR. CHAS. GIBSON (New York City) said that failures in procedures are not necessary in any case of large ventral incisional hernia. He said that with confidence from a very considerable experience in which he had never had anything approaching failure.

The procedure is described by him in a paper read before this Association at St. Louis in 1920, called, The Fascia Flap Operation for the Cure of Large Ventral Hernias. At that time he reported his only failure, in a man who had been operated on six times before unsuccessfully and who had a hernia running from the ischium to the pubis. His failure was in a small gap which the man tolerated well. That was his last failure.

The great bulk of these cases have been operated on, by all kinds of procedures, by surgeons, some of them of great skill. Many of these patients have been very large and obese. One man he presented at various times before the New York Surgical Society, and others also have very typical cases; no patient died. He had never refused a single patient. He believed from his personal experience that there is not a single case of ventral hernia that cannot be cured by careful, sometimes very laborious reconstruction of the abdominal wall and the so-called fascial flap.

Of course, the fascial flap is only a step in the whole thing. One must unsnarl the whole mess and be able to release such muscles as remain. A good many are destroyed in straightening them out, but that can be done very well, but still there remains the fascia, and he had made an incision on either side for a suitable size and suitable length. In the average cases the releasing incision would be three or four inches, and situated an inch and a half to two inches from the mesial line.

Almost always when he had spoken on this subject somebody had felt very anxious and very worried lest at the site where the releasing incision was made there should be a weakness. None of these cases has developed this horrible, theoretical weakness. Careful work in any of these hernias can be absolutely assured in something approaching 100 per cent. of the cases.

DR. ELLSWORTH ELIOT, JR. (New York City) emphasized the advantages of closing hernial orifices, the edges of which cannot be approximated and overlapped without

undue tension, with completely detached segments of fascia lata. One of the largest orifices of this kind followed the sloughing of the entire anterior abdominal wall, both above and below the umbilicus, the result of a wide infection following a pan-hysterectomy at the hands of another surgeon. In this instance a large segment of fascia lata, superimposed upon the peritoneal tissues, was placed in the defect, the border of the segment being sutured to the deep surface of the freshened lateral aponeurosis an eighth of an inch from its edge, which in turn was sutured a corresponding distance to the anterior surface of the transplant, giving the appearance of a "double-breasted coat." The suture material was chromic gut. The skin and subcutaneous tissue were then brought together over the fascial flap.

Prompt union followed and for three years following, at the end of which time the patient succumbed to a pneumonia, there was no indication of a recurrence or of any tendency to an enteroptosis.

DR. HOWARD LILIENTHAL (New York City), in the operation of splenectomy, especially when the organ is large, preferred an incision beginning beside the xyphoid running downward paramedially as far as seems necessary, then making an incision to connect with the upper end of the first one and passing close to the costal arch as far as the seventh or eighth rib-cartilage. The flap thus formed can be turned downward and the entire region can be beautifully exposed by retraction of the costal arch upward and outward. If necessary one or two ribs may be divided for simplicity in exposure. None of the lower intercostal nerves is interfered with, nor is there any paralysis of the recti muscles; the nerves which are cut unite nicely. He had had one patient who went through a pregnancy and confinement without undue stretching of her abdominal wall and with perfect recovery of abdominal function afterward.

Hernia is likely to occur in inverse proportion to the distance of the wound from the lowest part of the abdomen.

The incision described by him is through the fascial tissue parallel with the costal arch and permits excellent repair by suture.

When he first did this operation it was original with him but he had since found that others have used it.

DR. WILLIAM B. COLEY (New York City) felt very much as Doctor Gibson does about there being a small number of cases in which it is necessary to use a method of this sort. He likewise had succeeded in closing very large abdominal openings by overlapping the fascia and using kangaroo tendon which is really a heterogeneous fascial suture.

He had been very greatly interested in the operation which Doctor Gallie brought out over ten years ago for treatment of large recurrent and direct hernias by means of living fascial sutures.

The first Gallie operation at the Hospital for the Ruptured and Crippled was performed by Dr. Bradley L. Coley. The method was quickly adopted by the other members of the Hernia Division, and up to the present time 1,060 Gallie operations have been performed at this hospital, as follows: *First series*.—Autogenous (human fascia), 798, with sixteen (2 per cent.) deaths; sixty-six (8 per cent.) infections; forty-three (5 per cent.) recurrences during first year; and forty-four (15 per cent.) recurrences after the first year. *Second series*.—Homologous (human fascia), seventy-five, with five (7 per cent.) deaths; nine (12 per cent.) infections; five (7 per cent.) recurrences during the first year; and six (30 per cent.) recurrences after the first year. *Third series*.—Heterologous (ox fascia), 195, with one (.5 per cent.) deaths; eighteen (9 per cent.) infections; sixteen (8 per cent.) recurrences during the first year; and fifteen (18 per cent.) recurrences after the first year. The total recurrences were 129 (29 per cent.); and the total deaths twenty-two (2 per cent.)

These figures show that the fascial-suture operations have had a mortality about

ABDOMINAL INCISIONS AND THEIR CLOSURE

six times as great as that found in a series of 3,000 consecutive herniotomies at the Hospital for Ruptured and Crippled during a period of three years and nine months prior to our first use of fascia, the mortality being 1 in 300 cases in the earlier series as opposed to 2 in 100 cases in this series of fascial suture cases.

The percentage of infections in the fascial-suture cases is not appreciably higher.

The recurrence rate seems surprisingly high (29 per cent. of all cases of all types). However, these figures are based on a careful follow-up examination by various members of the visiting staff of the two hernia divisions of the hospital, and they are obtained by taking the number of known recurrences and figuring the percentage based only on those cases followed more than one year. If the total number of known recurrences were figures on the basis of the total number of operations performed, the percentage of recurrences would fall to nearly one-third of the figures as given.

Percentage recurrence rates should, however, be figured only on the basis of followed cases.

It is regrettable that but 36 per cent. of the total number of cases operated upon could be traced longer than one year. Conditions of life among the clinic class in a large city, ignorance, indifference, and the floating character of our population are obstacles which can be met with only partial success.

DR. J. TATE MASON (Seattle) called attention to the bayonet type of incision that was suggested some years ago. It is especially useful where one has difficulty in getting adequate exposure in the upper abdomen. There are no muscle fibres cut and very few nerves severed, and it gives the greatest exposure one can obtain in the abdomen because it embodies a longitudinal and a transverse incision in one. The incision is begun high up on the inner third of the left rectus, is carried down to within two and one-half centimetres of the umbilicus, and is then brought transversely over to the right rectus and continued down the inner third of this muscle for three or four centimetres or as far as one needs exposure. The anterior sheaths of the muscles are then opened and the muscle fibres retracted laterally.

The only criticism that might be made would be as to the possibility of a post-operative hernia through the transverse part of the incision. He did not know at this time how many of these incisions they had performed, but in the fifteen years since this type of incision has been used they had had very few hernias. The transverse part of the incision is closed first. This procedure is based upon Dr. W. J. Mayo's operation for umbilical hernia, which he described before the American Medical Association about 1903, in which the transverse incision is imbricated. This is the only part of the operation where one needs to use particular care. He emphasized the importance of closing this part of the incision first.

DR. W. E. GALLIE (Toronto) said that in presenting this method of closing large hernias he should make it clear that it is one that is not often necessary. He had found, however, that his friends had accepted the various papers he had written on hernia as more or less of a challenge and had sent him cases the like of which he had never seen or heard of. As a result he was forced to devise a method which would hold out a reasonable hope of cure.

He had no doubt there are lots of other ways of curing difficult hernias besides the one he had described. He must say, however, that he was not so much interested in them as in his own method.

DR. ARTHUR DEAN BEVAN (Chicago) said that he understood that Doctor Gallie employs his method in very difficult cases. He himself had done, as Gibson has done in the ordinary post-operative hernia, and had used the fascia that was at hand, without transplanting.

He had, however, introduced one important point in connection with the use of that fascia and that is what they call their vertical imbrication. Instead of imbricating

one layer above the other they very often in the difficult post-operative hernias make a vertical imbrication with three rows of stitches, so bringing a broad surface of the fascia in contact and holding it in contact with three rows of sutures. They have really gotten, by such a vertical imbrication, better results than with anything else.

He was sure, however, that with difficult cases, with destruction of the fascia, that the method that is presented by Gallie is very much worth while. I think it really enlarges our ability to handle some of these difficult problems.

In regard to Doctor Lilienthal's modification of the Kocher incision, if he will take an anatomy, he will find that his incision divides most of the nerves of the abdominal wall.

The problem which they had been working on was to attempt to make incisions which would give adequate exposure without any injury to the nerve supply. It is not alone paralysis; it is the trophic changes which occur which favor hernia, and not only the nerve supply but also the blood supply. There is really no reason any longer, and there never has been very much, to make these tremendous incisions which are so destructive of the important structures in the abdominal wall.

HERNIA OF THE URETER

BY ALEXIS V. MOSCHCOWITZ, M.D.

OF NEW YORK, N. Y.

I DOUBT that it will create much controversy if I assert that the operation for the radical cure of hernia is one of the most frequent, if not actually the most frequent, operation of present-day surgery. So frequent indeed, that the operation has lost caste and has come to be looked upon as a sort of minor procedure and one which in many clinics is often relegated to one of the junior assistants. I have always been averse to this shiftless method of dealing with the hernia problem and on many an occasion have so expressed myself in vigorous and sometimes undiplomatic language. This difference of opinion arose because of the undeniably frequent recurrences even in the hands of expert surgeons. I was therefore rather gratified to find that so eminent a surgeon as Schmieden as recently as 1929 (*Archiv für Klinische Chirurgie*, vol. clvii, p. 122) at a meeting of the German Surgical Society expressed his views regarding this subject in the following words: "The operation for inguinal hernia is looked upon as simple and easy; it is often treated with little respect and is left to the beginner, a frequent cause of the bad result. The surgeon who desires good results must look upon the operation as one of importance. I do not consider the operation easy. . . . Let us all again look upon the (well-executed) operation as a (surgical) masterpiece." If this is true, and, as far as I am concerned, I agree with Schmieden unequivocally, of the simple and uncomplicated herniæ in which only the question of recurrence arises, how much more true is it for herniæ with complications of one or another nature! I have personally called attention to some of these. Thus for instance, in describing the pathogenesis of herniæ of the large intestine in general and of sliding hernia in particular (*ANNALS OF SURGERY*, vol. lix, p. 610), I made the statement that there is hardly any operation that may tax the patience and technic of the best-equipped surgeon more. In another part of the same article, when discussing the frequency of sliding hernia, I ventured the opinion that the paucity of case reports is very probably due to the fact that "the operator did not wish to be reminded of a rather unpleasant experience."

When I operated upon Case III of this series of hernia of the ureter, I was so impressed with the difficulty of the operation and with the possibility of injuries of the ureter, that I then and there determined to review both my own and the published cases in order to again call attention to same. The real motive, however, was furnished me when I found, upon mentioning my latest case of hernia of the ureter to some colleagues, that they chided me and denied not only the occurrence but even the possibility of this variety of hernia. No one can deny the rarity of this form of hernia, the possibility is

proven, however, by my own cases and by several well-authenticated case reports in the literature both here and abroad.

The pathogenesis of ureteral hernia is that of sliding hernia in general, which I have fully described in the article previously referred to. In other words, we find among ureteral herniæ, just as among all sliding herniæ, two varieties, namely, very large herniæ which have been formed by a pulling mechanism and in which a rather large section of the ureter has become herniated, and small herniæ, which are produced by the so-called pushing mechanism and in which the herniated portion of the ureter is correspondingly short. The latter usually occur in combination with hernia of the bladder and only the very lowest portion of the ureter becomes involved in the hernia. Not infrequently, the latter are of the femoral variety. In reality, there exists also a third variety which may be called an intermediate or mixed group, in which it is difficult to determine the exact mechanism of production. I have in mind one such instance in my personal experience, in which the hernial contents were rather manifold, namely, an ovary and tube with a cornu of the uterus, the sac was made up principally of the unfolded broad ligament behind which there was noted a section of the ureter about two inches in length, very probably the juxtavesical portion of same.

The question that interested me much more, however, was just why there exists so much scepticism in the minds of surgeons of repute and experience even as to the possibility of the occurrence of a hernia of the ureter. This interesting phase is very likely due to the generally prevailing impression that the ureter, being located entirely extroperitoneally and therefore not having a true peritoneal coat, has nothing further to do with the mobility or movements of the peritoneum. But this prevailing impression is entirely erroneous as I have been able to prove to myself, not only in operations upon the ureter, but also in the dissecting room. I have found, namely, that the lower abdominal and pelvic portion of the ureter is intimately adherent not, as one might surmise, to the structures of the posterior abdominal and pelvic parietes upon which it lies, but to the peritoneum which covers it in front. If this were not the case, then hernia of the ureter would be an absolute impossibility; but as it is in reality, the position of the ureter is analogous to the position of the ascending or descending colon—the only difference being that the peritoneal covering of these structures is somewhat more closely attached to the underlying muscular coat than it is to the ureter.

If this elementary but nevertheless fundamental point in the surgical anatomy of the ureter and its relationship to the peritoneum is thoroughly appreciated and understood, then the formation of a hernia of the ureter becomes not only plausible and possible, but in combination with certain definite circumstances, even probable. The presence of a sliding hernia of the ascending or descending colon has so often been demonstrated by operative findings that when one considers the close proximity in the retroperitoneal space of these structures to the corresponding ureters, it is only surprising that the ureter is not a more frequent finding in these.

It is but a very short distance from the peritoneal sac of a sliding hernia of the descending or ascending colon to the peritoneal sac of a hernia of the cæcum or sigmoid flexure, necessarily of the non-sliding variety. Let us now assume for the sake of argument that the latter hernia has increased just a trifle more, and let us assume furthermore, as it really is, that the previously described relationship of the ureter to the peritoneum is correct, then it will be readily seen how the ureter will be dragged down with any further increase in the size of the hernia. If that is the case, we may have a non-sliding hernia of the cæcum or lowermost portion of the ileum in combination with a sliding hernia of the ureter. As I have developed the formation of this hernia, it will be readily seen that this particular hernia must be of large size, and, in consequence, must have been formed by the so-called "pulling" mechanism.

For the formation of a hernia of the ureter by the so-called "pushing" mechanism, we must assume favorable relationship and proximity of the bladder and of the adjoining portion of the ureter to a hernial opening. A knowledge of anatomy will at once suggest that this is much more probable in femoral and direct inguinal hernia than in oblique inguinal hernia, though the latter is by no means excluded. It is surprising how frequently the bladder is found in all three of these by the careful dissector; on the contrary, when isolating the sac for a very high ligation, I hardly ever fail to visualize the fatty covering of the bladder. If the postero-lateral part of the bladder is extruded, it cannot be surprising if a small segment of the ureter also becomes extruded. This would therefore be a sliding hernia of the ureter by the "pushing" mechanism.

The treatment of a hernia of the ureter does not differ from that of any other hernia and very little need be said upon the subject. The only important point during the operation is to recognize the ureter when seen and if recognized, not to injure it. No specific directions can be given regarding the recognition, excepting the self-evident one, which is applicable to every hernia operation and for that matter to every operation whatever its nature, namely, not to cut or divide anything unless one knows absolutely what that particular structure is. In operations for hernia of the ureter, in particular, caution must be exercised with any cord-like structure which may be encountered upon the extraperitoneal surface of the sac. In the order of their frequency, these can be only the vas deferens, round ligament, the tube, the obliterated hypogastric artery, the vermiform appendix and the ureter. I believe the differentiation of the first three is so characteristic that it need not detain us further. The physical characteristics of the ureter are not particularly marked. Above all, it lacks the peculiar wiriness of the vas deferens and of the obliterated hypogastric artery, and, odd as it may appear, in the few cases it has been my good fortune to encounter it in a hernia, it appeared to me to be rather more ovoid than circular, but this may have been due to haste in my observation, and no one will blame me for haste in the course of a rather extensive and strenuous operation. The important point to be emphasized is to remember not to injure, or, worse still, divide the odd-looking cord-like

structure on the posterior surface of the hernial sac. It may appear peculiar that I lay so much stress on this point, but I am constrained to do so because it is an accident which has happened in the most expert hands, has cost dearly, even life, and may happen again. The proper way of dealing with the ureter is to dissect it with great care off the external surface of the sac and to replace it as well and as neatly as possible into the retroperitoneal space of the abdomen, a manœuvre much aided by elevating the patient into Trendelenburg's position. In one of my cases (CASE III) so large a section of the ureter was prolapsed that I feared a kinking of it when replaced haphazardly into the retroperitoneal tissues, an accident I obviated by placing the patient after the operation into a rather exaggerated Trendelenburg's position for a few days.

Watson (Hernia, S. V. Mosby Company, St. Louis, 1924) in discussing hernia of the ureter gives a complete bibliography of the subject up to the date of his publication to which those interested are referred. He states that in 1923, he collected from the literature forty-seven cases of ureteral hernia. I have been unable to find any additional cases reported since that time. I have encountered four cases of ureteral hernia which would bring the total up to fifty-one.

My cases are the following:

CASE I.—Deborah L., fifty-five years of age, was admitted to Mt. Sinai Hospital in the service of Dr. Arpad G. Gerster to which I was then attached, September 21, 1913. She gave a history of the existence of a left-sided hernia of several years' duration which had given symptoms of strangulation, namely, generalized abdominal colic, nausea, vomiting and complete obstipation for four days. Physical examination revealed the presence of a strangulated femoral hernia. I operated upon her, as I am accustomed to doing, through an inguinal incision. The operation revealed a strangulated but viable Richter hernia of the small intestine. In clearing the sac, the ureter was discovered skirting along the outer surface of the sac running inward in order to reach the bladder. The ureter was carefully dissected away from the sac, replaced and the radical operation finished in the customary manner. No untoward symptoms arose and patient was discharged well, October 18, 1913.

CASE II.—I greatly regret that after a very strenuous search of the histories of Mt. Sinai Hospital, I failed to find the history of this patient. My only record of it is a short reference in Johnson's *Operative Therapeutics*, vol. iv, p. 68, where, in the chapter on ureteral hernia, I mention two cases. The first case is Case I just reported and the second case is the present one. Although I do not possess the exact history, the important points are so vividly impressed on my memory that I may be permitted to quote from it. The patient was a young woman afflicted with a hernia on the right side, in which on account of the peculiar sensitiveness, a pre-operative diagnosis of an ovarian hernia was made. I was much gratified when I found that the operation verified my pre-operative diagnosis. The further development of the operation revealed in addition to the ovary the presence of the tube and the right cornu of the uterus. The posterior part of the sac was rather puffy and investigation as to the reason for same showed it to be the unfolded right broad ligament. In order to be able to ligate the sac properly, it was necessary to get behind the broad ligament, and, when this was accomplished there was seen on its posterior surface a cord-like structure which was recognized to be the ureter. It was carefully dissected off and replaced into the retroperitoneal tissues. The

HERNIA OF THE URETER

rest of the operation was presumably of no importance, as it made no lasting impression upon me.

CASE III.—Phillip S., fifty-four years of age, a potential diabetic, was referred to me by Dr. S. Bernstein for the cure of a hernia in the right groin. The physical examination revealed a rather obese individual suffering from a right oblique inguinal hernia the size of a grapefruit, which began fourteen years ago and for which no adequate support was ever worn; in addition to the above, there was also found a left-sided direct inguinal hernia about the size of a hen's egg. I suggested that the large right-sided hernia be operated upon first and if, at the termination of this operation, the condition of the patient warranted it, to proceed with the operation upon the left side. The operation was carried out in general anaesthesia, October 22, 1931, and proceeded perfectly smoothly up to the separation of the sac, except that a large piece of the omentum had to be resected. When the sac was being peeled off, there was noted upon its posterior surface a cord-like structure which was entirely different both in shape, structure and position from the vas deferens and obliterated hypogastric artery and incidentally, I may mention that both these structures were subsequently isolated and recognized as such. The cord, I should say, was not quite round but somewhat ovoid in shape and about one-fourth of an inch in diameter; its outer coat was made up of what appeared to be smooth muscle fibres of a pinkish color. After complete isolation of the sac, the cord was seen to emerge from the internal inguinal ring, descend upon the posterior surface of the hernial sac, make a loop or curve near the fundus, then ascend again upon the posterior surface of the sac, return to the internal inguinal ring where it was lost to sight. It was recognized immediately to be ureter and demonstrated to one of the visiting surgeons, who happened to be present, and several assistants. It was then dissected very carefully from the sac and replaced into the retroperitoneal tissues. Owing to the length of the section of the prolapsed ureter, this was a rather difficult manoeuvre but was finally accomplished, I confess, in a rather haphazard manner and only with the aid of Trendelenburg's posture. From this point onward, the operation did not differ from any ordinary uncomplicated hernia. When the patient was returned to his room, the foot of the bed was elevated extremely; I hoped by this manoeuvre to elevate the kidney and thereby straighten out the ureter. It is rather difficult to estimate of how much benefit this manoeuvre was—suffice it to say, however, that the patient made an excellent recovery without any complications as to kidney function or kidney drainage. When the patient was convalescent, I made an attempt to outline the ureter by an intravenous administration of iopax, but it was not satisfactory and because of the recent operation I did not wish to subject the patient to a cystoscopy. The patient was discharged well November 8, 1931.

This article was already finished and in manuscript when I encountered the following case:

CASE IV.—Miss S. S., sixty years of age, had never been ill prior to her present illness. Twenty-four hours before I saw her, she complained of cramp-like pains in the abdomen and inability to move her bowels or pass flatus; both of these symptoms, however, soon corrected themselves. In spite of this apparent improvement, she consulted her physician and was well enough to visit him at his office, where I also was invited to see her about 1 P.M. April 17, 1932. My examination revealed a somewhat tender right-sided femoral hernia. Her general and local condition, however, were excellent and as her bowels had moved very freely, I made the diagnosis of a strangulated femoral hernia and unhesitatingly stated that most probably, the contents were a bit of omentum and in consequence, postponed operation until the following day. My surprise and chagrin may therefore be imagined when I found that the presumed bit of omentum turned out to be not omentum but strangulated small intestine in the form of a Richter hernia, fortunately in a viable condition. A further complication was the following:

When the sac was pulled up into the inguinal region from its femoral location, as I am accustomed to doing in all operations for femoral hernia, I proceeded to clear the sac of all extraneous tissues and had already transfixed it preparatory to ligation when I noticed on its outer and posterior surface a somewhat ovoid cord-like structure which did not belong there. I proceeded to investigate this cord and found that it made its exit from the retroperitoneal space, then descended upon the postero-external surface of the sac for a short distance, then turned mesially and was lost in the juxtavesical fat which was present and recognized as such prior to the discovery of the ureter. The cord-like structure could only be either the ureter, the round ligament or the tube; only the ureter came into consideration, however, as all the other structures were identified. The ureter was carefully dissected off the peritoneum, a not at all easy matter owing to its dense adherence to the latter; when liberated, it was about three inches long. It was replaced into the retroperitoneal space and the operation finished in the usual manner. At date of this writing, patient is still in the hospital but has made an excellent and uncomplicated recovery.

The four cases cited above bring up the total number of cases of hernia of the ureter to approximately fifty-one. It exists in both sexes and may be of the inguinal or femoral variety.

I have been much interested throughout my entire career in what may be termed abnormal herniæ, but which I prefer to call hernia out of the ordinary. Hernia of the ureter is not only out of the ordinary, but is so extraordinary that its very existence has been denied by outstanding surgeons. My own cases as well as the sparse cases reported by very excellent observers not only prove their existence, but to my mind, warrant this publication.

DISCUSSION.—DR. HOWARD LILIENTHAL (New York City) believed that it would have been a simple matter to catheterize the ureter through the bladder, and also, that methylene blue might be injected through a fine needle passed obliquely through the urethral wall into the ureter and that the dye could then be easily and immediately recognized in the urine.

DR. ARTHUR D. BEVAN (Chicago, Ill.) asked whether any of these cases were associated with sliding hernia of the bladder or were they entirely independent of such condition.

DOCTOR MOSCHCOWITZ.—Some of the cases of uretral hernia reported were associated with a sliding hernia of the bladder, others were not.

THE SURGICAL TREATMENT OF HÆMORRHAGIC DUODENAL ULCER

BY DONALD C. BALFOUR, M.D.
OF ROCHESTER, MINN.

HÆMORRHAGE is one of the major complications of peptic ulcer. Its occurrence is serious, not as a cause of death, since it is rarely fatal, but because of the disability associated with a massive hæmorrhage, the uncertainty as to outcome and the fact that the patient believes that recurrence of the hæmorrhage should be preventable. Hæmorrhage from a peptic ulcer, therefore, though not a great menace to the life of the patient, is certainly a menace to his health and to his peace of mind. Since hæmorrhage from a duodenal ulcer presents problems which are not encountered from bleeding associated with gastric ulcer, I shall confine this consideration to hæmorrhagic duodenal ulcer.

It is difficult to determine the liability of hæmorrhage from duodenal ulcer. Although in about 20 per cent. of cases coming to operation for duodenal ulcer a history of hæmorrhage is obtained, this does not represent the true incidence of the complication since it may occur in cases in which operation is not performed and the patients may be entirely unaware that bleeding has taken place. In consecutive cases in the clinic, in which the diagnosis was duodenal ulcer, a history of definite hæmorrhage is given in about 10 per cent., but if the course of the disease in the non-surgical case is followed over a period of ten years after the positive diagnosis is made, the incidence will be increased to about 25 per cent. This also does not represent the total liability, since it is not uncommon for the complication to occur at a period later than ten years.

The significance of a gastro-intestinal hæmorrhage occasionally presents a difficult problem. In a case of proved duodenal ulcer it may reasonably be assumed that a frank hæmorrhage is due to the ulcer, but it is well to keep in mind that other factors may exist which directly or indirectly are responsible. One of the causes of disappointing results following surgical treatment of duodenal ulcer in a case in which one or more hæmorrhages have occurred, is the overlooking of these other factors; for instance, lesions of the spleen, liver, small intestines, or chronic infections.

The most difficult group of cases is that in which hæmorrhage occurs without previous symptoms of ulcer, and in which exhaustive clinical and röntgenological examination subsequent to the bleeding fails to disclose a lesion. In such cases the hæmorrhage is usually due to an inflammatory process in the duodenum which is not sufficient to disturb gastric function and produce symptoms, or to give direct or indirect evidence of its presence by röntgenological examination. Such cases are puzzling, but fortunately

they are relatively rare, and if the hæmorrhage is repeated, the cause usually becomes evident in the positive data afforded by röntgenological examination.

The mechanism of hæmorrhage is not clearly understood. It cannot be explained satisfactorily, for example, why massive bleeding occurs from a duodenum which shows little, if any, ulceration of the mucosa. Mann's explanation that it is due to the traumatizing of granulating buds in the base of a healing ulcer would seem most reasonable for the majority of cases of actual ulceration. The more rare hæmorrhage, due to erosion of an artery, is easily understood.

In the absence of sufficient ulceration to explain the hæmorrhage, the rôle of the liver must be considered. W. J. Mayo has always strongly emphasized the importance of eliminating all possible factors when recurrence takes place in cases in which there does not appear to be sufficient pathological change in the duodenum to account for the attacks. It is quite possible that the same infection which exists in the duodenum has involved the liver and set up cirrhotic changes, as Rolleston pointed out and described as latent cirrhosis. It is important, therefore, to use every means to determine by tests of hepatic function whether the liver is involved.

Similarly, every method of detecting splenic enlargement, especially by röntgenology, should be employed. In some cases, the explanation of persistently recurring hæmorrhages is obscure and disturbance of the portal circulation offers the most plausible reason. It is significant clinically that hæmorrhages which the inflammatory condition of the duodenum does not fully explain are not fatal, whereas those which are fatal can be shown to be due to erosion of a large vessel in the base of the ulcer.

Differential diagnosis must further exclude other extraduodenal lesions within the abdomen. The most definite of these are lesions of the small intestine (tumors, ulcerations or Meckel's diverticulum with aberrant gastric glandular tissue in its wall), appendix, and so forth. Such lesions are so well concealed that repeated operations may be carried out without avail for a duodenal ulcer erroneously supposed to be responsible for the bleeding. It is, therefore, imperative in operating for hæmorrhagic duodenal ulcer to recognize that some other lesion within the abdomen may be a factor, or possibly the only factor, responsible. This is particularly true in cases in which failure to control the bleeding has followed operation for the duodenal ulcer. This fact should not be emphasized beyond the point, however, that by far the most common cause of hæmorrhage is duodenal ulceration.

The treatment of acute hæmorrhage at present is usually non-surgical, since patients generally recover without operation. I believe, however, in exceptional cases when the bleeding continues and the presence of an ulcer is known, that massive transfusion of blood, followed immediately by a direct surgical attack on the ulcer, is sound treatment. It is an interesting fact that the greater the experience of the surgeon in this field of surgery, the more likely will he consider the advisability of operation in certain acute cases. The situation parallels that of pulmonary embolism, in which embolectomy

becomes justifiable if the patient is obviously dying. If, in spite of repeated transfusions, circulation cannot be maintained, operation could be looked on as justifiable and should consist of a direct attack on the ulcer, either by excision or by suture.

The surgical treatment of the hæmorrhagic duodenal ulcer is the chief purpose of this paper. The indications for operative measures are clear when frank hæmorrhage has occurred in a case of chronic duodenal ulcer, the symptoms of which have been inadequately controlled. A massive hæmorrhage apparently threatening the life of the patient justifies operation even if other symptoms are slight or absent. Recurring hæmorrhage with intervals of complete freedom of all symptoms and complications for varying periods is adequate reason for operation.

A single hæmorrhage of moderate severity, if the patient suffers little inconvenience from the ulcer, is not sufficient grounds for advising operation. A difficult problem is presented by the patient with recurring hæmorrhages, the cause of which cannot be definitely established because of the absence of other symptoms and because röntgenological studies of the gastrointestinal tract are either negative or inconclusive. Exploration should be advised in such cases and a lesion of the duodenum will probably be discovered, usually of the posterior wall, and more distant from the pylorus than such lesions commonly occur. Although it is apparently true that a slight inflammatory process without actual ulceration in the duodenum may be responsible for a single hæmorrhage, and also be difficult to detect at operation, it is also true that recurrences due to lesions in the duodenum are dependent on real ulceration, often completely concealed until the duodenum is widely opened.

The successful surgical treatment of hæmorrhagic duodenal ulcer demands familiarity with various surgical procedures, their indications and their proper performance. Gastroenterostomy can be fairly placed first in importance, because of its safety, its applicability to all cases and its efficiency in bringing about healing of the lesion, or lesions, in the duodenum. These facts give it very distinct advantages over all other operations. A review of the results of gastroenterostomy (posterior or anterior) for hæmorrhagic duodenal ulcer five years or more after operation shows that 85 per cent. of the patients have had no further hæmorrhages and have had no further symptoms of ulcer; such results frequently deter the surgeon from attempting operations more radical in principle and consequently of greater risk. There are two main disadvantages to gastroenterostomy. First, it may fail to prevent reactivation of the inflammatory process in the duodenum—I believe this is extremely rare if the gastroenterostomy has been properly performed and continues to function well. Secondly, recurrence of ulceration may take place in the jejunum. This complication occurred in about 4 per cent. of the cases in which gastroenterostomy alone had been done for hæmorrhagic duodenal ulcer during a period of five years or more after operation. It is of interest to note in such cases that recurrent jejunal ulcer is usually of the bleeding type and this adds to the probability that

there is an abnormal tendency to bleed in certain cases of ulcer. Recurrent jejunal ulcer does not present as serious a problem as one might be led to believe for the simple reason that there is little risk in disconnecting the gastroenterostomy and a method of treatment which has probably brought about complete healing of the primary lesion has been discontinued. It is usually advisable, however, in such cases, also to excise or resect the healed area in the duodenum by whatever method seems best under the circumstances.

The principle of direct attack on the hæmorrhagic duodenal ulcer is logical. The advantages of thorough removal of the lesion combined with a procedure which will prevent its recurrence are obvious. Theoretically and in actual fact, complete excision of the ulcer combined with gastroenterostomy satisfies both requirements, and when this can be done without introducing a too mutilating and, therefore, dangerous technical procedure on the duodenum, it becomes a most efficient method of treatment. The obstacles to such treatment are usually technical, because of the situation of the lesion, the obesity of the patient, or the fixation of the duodenum. Even if direct attack is interfered with by such conditions, partial removal with deep sutures carefully placed on the vessels of the gastrohepatic omentum leading to the site of the ulcer are useful. Cautery excision followed by suture can be satisfactorily employed as a quick and efficient method of handling lesions on the anterior wall in particular. For lesions on the posterior wall awkwardly situated it possesses definite advantages over other methods of excision. Direct excision also usually permits satisfactory inspection of the entire first segment of the duodenum, and the information thus acquired is of the greatest importance in solving the problem as to the most efficient treatment.

Another general principle of surgical treatment of hæmorrhagic duodenal ulcer is excision followed by reconstruction of the pyloric outlet. Such treatment is based on sound surgical principles, since in carefully selected cases it fulfills the major requirements of removal of the lesion, adequate modification of gastric physiology and minimal risk. The advantage of a thorough inspection of all of the first part of the duodenum is more positive with this type of operation, since with the wide removal of the anterior half of the pyloric muscle and the adjacent portions of anterior wall of stomach and duodenum excellent exposure of the posterior wall of the duodenum is possible. The second advantage, namely, the elimination of the factor of pylorospasm, in many cases at least, is of the greatest importance since it accomplishes in them control of the disease. The risk of the operation, when cases are carefully selected, is less than any other procedure. In the last 400 operations of this type, the mortality rate was .27 per cent. The protection against further hæmorrhage was at least 70 per cent. and in cases in which recurrence does take place a different type of operation easily can be done and usually is followed by good results.

The principle of duodenal exclusion is one which merits attention, because inflammatory processes in the duodenum when completely excluded from all gastric secretion are almost certain to heal and remain healed. In

the earlier application of this principle, as by the method of von Eiselsberg, of dividing the pylorus, the disappointing results were due to the high liability to jejunal ulcer because of the secretory products of the entire stomach being diverted into the jejunum. Devine modified this procedure by dividing the stomach well above the incisura, closing the lower segment and restoring gastro-intestinal continuity by some form of gastrojejunostomy. Insufficient data concerning late results necessitate reservation of opinion as to its efficacy in preventing the development of jejunal ulceration, but it is most efficient in promoting healing of the primary lesion. Finsterer, in certain cases, employs the principle but adds removal of the pyloric antrum on the assumption that the antrum is a factor in promoting the secretion from the acid cells of the fundus. I believe the operation is one which should be included in the list of useful procedures for hæmorrhagic duodenal ulcer.

The most thorough treatment for hæmorrhagic duodenal ulcer is partial duodenectomy combined with gastric resection. Such a procedure satisfies best the requirements for good ultimate results in that it removes the vulnerable portion of the duodenum and brings about such a profound change in gastric physiology that those factors, mechanical and chemical, which were chiefly responsible for the ulceration are more or less completely and permanently controlled. In this respect the operation is not equalled by any other procedure. The operation, however, has the very unfortunate disadvantage of being of much greater risk than any of the other procedures, a disadvantage made greater by the fact that the conservative procedures will bring about the same results in a high percentage of cases. I am convinced, however, that since partial duodenectomy and gastric resection reduces to a minimum the recurrence of ulceration that it should be employed when it can be done without greater risk than more conservative measures. This requires experience, judgment and a reasonably accessible duodenum. The method of restoring continuity will vary with the condition of the duodenal stump. Billroth No. I is, I believe, preferable when it is feasible; in some cases after the method of Finney and von Haberer. In cases in which such anastomosis is impractical, a hook-up of fundus and jejunum by one of the many methods is indicated. It is true that such an operation does not absolutely insure against recurrence. I have, within the month, operated upon two physicians with recurrent bleeding jejunal ulcers following gastric resection for hæmorrhagic duodenal ulcer. It so happened that in both these cases the recurrence apparently could be at least partly attributed to too little resection. A very useful surgical procedure for recurrence which takes place under these circumstances is resection of the jejunum, end-to-end jejuno-jejunostomy, reresection of the stomach and reimplantation of the stomach into the second portion of the duodenum.

The surgical treatment of hæmorrhagic duodenal ulcer is a difficult problem and disappointing results may follow any procedure. An attempt to establish a routine method of treatment increases morbidity and mortality, and as it is true in uncomplicated duodenal ulcer, it is even more true in

ulcer complicated by hæmorrhage that careful selection of the operation best suited to all the conditions met in the individual case is the best form of treatment. The importance of being certain that the sole cause of the hæmorrhage is in the duodenum, and the low operative mortality rate of effective conservative procedures, cannot be overemphasized.

DISCUSSION.—DR. GEORGE W. CRILE (Cleveland, Ohio) discussed the biological method of producing an arrest of hæmorrhage which is based upon the work of Doctor Cannon, who showed that in the presence of a hæmorrhage of considerable proportion, there is excited an increased output of adrenaline and the effect of adrenaline is that of promoting clotting. Upon this point of view Doctor Crile initiated a method to be used in case of internal hæmorrhage from a duodenal ulcer or any other cause. The surgeon himself sits by the bedside, putting a light tourniquet on each thigh, applying just sufficient pressure to prevent the flow of blood from accumulating in the extremities, and has the patient propped up on a pillow until the patient is about to faint. The fainting, the last ditching in before death, will arrest hæmorrhage, and principally because it excites an increased flow of adrenaline. The surgeon sits by the bedside watching the patient's condition and allowing him to go on bleeding until the condition of a moderate fainting is induced. Then the patient is allowed to lie down and first one then the other tourniquet is released so that the blood comes back to the extremities gradually.

It nearly always happens that a hæmorrhage can be arrested by this process.

DR. LINCOLN DAVIS (Boston, Mass.) spoke of that aspect of bleeding duodenal ulcers that Doctor Balfour mentioned in which he understood him to say that he thought where there was an erosion of the gastroduodenal artery, little could be done.

The speaker had had very unfortunate experiences with three such cases. In one case there was a massive sudden hæmorrhage in a strong, robust Negro, which exsanguinated him; after a transfusion he was operated upon and the ulcer was approached by opening the duodenum and, when a clot was washed away, there was a terrific hæmorrhage from the base of the ulcer which was controlled only by placing the finger over the ulceration. It was a very difficult situation. The cautery was evidently out of the question. An attempt was made to put sutures across the floor of the ulcer and control the bleeding. Eventually the bleeding was stopped, but the outcome was unsuccessful.

A short time after that they had another case of the same type, a very sudden, terrific hæmorrhage in which there had been some evidence that the man had a duodenal ulcer. In this case, at the suggestion of Dr. D. F. Jones, he approached the ulcer in a different way, transecting the duodenum at the pylorus and turning the duodenum back and then tying off the gastroduodenal artery above and below and doing a Billroth I operation.

That patient also succumbed. He was in desperate condition and though he was transfused, he wasn't able to rally. Post-mortem examination showed an erosion of the gastroduodenal artery, that artery will bleed as freely as the radial.

A third case was not operated on at all. He had a massive hæmorrhage in the medical ward and was transfused two or three times, but he died and an autopsy showed another one of these eroding ulcers which had eaten through the wall of the gastroduodenal artery.

DR. F. N. G. STARR (Toronto) said, apropos of Doctor Crile's remark, it may perhaps be interesting to know that forty-odd years ago as a student in the office of the late Dr. W. T. Aikins, of Toronto, when he was approaching an operation in which there would likely be a good deal of shock or a considerable hæmorrhage, he invariably put a tourniquet on each arm and each leg and then when the operation was finished—and I may say during many of these there wasn't anything like the amount of bleeding that

was anticipated—and the dressing on, then the job was very gently to take off one tourniquet from the arm, the other from the other arm, one from the leg, and so forth.

Speaking of the bleeding duodenal ulcer, he thought Doctor Balfour had sounded a very good note in the endeavor to do the simplest types of operation that will cure. He had had the experience on several occasions of a patient coming in as a result of a serious hæmorrhage. Transfusion bucked them up and the patient was pretty well for two or three days. Then he noticed him getting pale and, doing a hemoglobin, it was found to be down again. He was transfused again, and again he improved, but the bleeding proceeded and there was still melæna in his stools; then operation seemed imperative.

Upon opening the duodenum, he found a posterior duodenal ulcer which was spurt-ing a tiny little stream in very tiny jets. The ulcer was either excised or cauterized and then oversewn, and afterward there was ligation of the gastroduodenal artery followed by a gastroenterostomy.

DR. JOHN H. GIBBON (Philadelphia) spoke about transfusions in the presence of, or following, profuse gastric hæmorrhage. He was convinced, with the intravenous method as at present employed, and with transfusions of large amounts of blood, that the mortality in gastric hæmorrhage has been very much increased. If transfusion is used at all, only very small amounts of blood should be given.

He had seen two or three patients who represented a course very much like that described by Doctor Starr. After each transfusion there was a temporary buck-up followed by another hæmorrhage. One of these patients made a very rapid recovery when transfusions were stopped and fluids given only under the skin and by the rectum.

DR. FRANCIS A. SCRINGER (Montreal) recounted a recent instance where a man came in with a sudden large hæmorrhage and vomited some 500 or 600 cubic centimetres of blood, in addition to blood from the bowels, in which the red cells went down to less than a million, in which there was difficulty in breathing, in which he had reached the point of fainting, and in which a small transfusion was given which improved him.

I may state in our experience these small transfusions of not more than 300 cubic centimetres of blood have not raised the blood-pressure appreciably, not more than above 4 or 5 per cent.

This man, whether on account of the blood transfusion or in spite of it, bled again another 500 cubic centimetres. He was again transfused and immediately operated upon. Just at the turn of the duodenum, there was a large bulge, almost like a diverticulum. In this was the ulcer on the upper surface, very much inflamed and attached to the pancreas. In that diverticulum was seen projecting a vessel quite as large as the lead of a pencil, which was actually bleeding at the time of the opening. Possibly the trauma had started it again.

The vessel was ligated and the ulcer obliterated by sutures. It had already been entirely denuded of mucosa.

DR. DONALD C. BALFOUR (Rochester, Minn.) thought the cases Doctor Davis had described to be extraordinary and yet he believed that the patient in such circumstances usually has to fight it alone—except for transfusions. At the same time, he said, one could have the impression that the bleeding vessel might be reached by operation and ligated or sutured. It is indeed fortunate, however, that the patients usually recover without operation.

The question Doctor Starr brought up, of operating on the patient who continues to bleed in spite of transfusion, is most important and there will be general approval of that method. If a patient steadily goes downhill with each hæmorrhage, we give a transfusion and open up widely to see what can be done, because the risk of operation under those circumstances is less than the risk of a patient's carrying on himself.

He agreed with Doctor Gibbon on the danger of transfusion, particularly massive transfusion in these patients. Such are ill advised, and the practice at Rochester is not to do it until a patient is apparently dying and then a small transfusion is given; repeated if necessary to carry the patient along.

CARCINOMA OF THE STOMACH—AN ANALYTICAL SURVEY

By GATEWOOD GATEWOOD, M.D.

OF CHICAGO, ILL.

THE fatalistic attitude common among physicians and patients has led me to make a survey of our carcinoma cases in the hope of discovering some remedial shortcomings and of improving our future results. Carcinoma of the stomach continues to lead the list of deaths from malignancy, the figures varying from 35 to 40 per cent. in the statistics of the various countries of the world.

In 1930, I reviewed the results of resection for gastric malignancy in patients operated upon during the preceding decade.¹ This survey includes *all* patients who entered the Presbyterian Hospital between January 1, 1920, and December 31, 1929, in whom the diagnosis of carcinoma of the stomach was made. Of these 417 patients, 209, or exactly 50 per cent., were discharged without operation for the following reasons:

Carcinoma of the cardia.....	30 or 14.4%
Previously operated upon*.....	17 or 8.1%
Too extensive (evidence of metastases, ascites, etc.).....	46 or 22 %
Too sick for operation.....	27 or 17.7%
Cause not stated (most of these were extensive carcinomas)...	50 or 23.9%
Refused operation (considered operable).....	24 or 11.5%
Went elsewhere for operation.....	5 or 2.4%

* Of the seventeen patients who returned after operations done prior to 1920, or done elsewhere, eleven had had resections and six gastroenterostomies.

The operative cases have been grouped as explorations, gastroenterostomies, resections and palliations such as gastrostomy or enterostomy. Although a slightly larger proportion of patients has come to operation during the past three years, there still were 45 per cent. who were either pronounced inoperable or refused operation.

Analyzing the histories of all of these patients, we find 308 males and 109 females, or a ratio of 2.8 to 1, which is a somewhat higher proportion than is usually found, although Ransom and Coller² report that 85 per cent. of the patients in their series were male. The ages varied from twenty-four to eighty-nine years, six being under thirty years of age.

An attempt was made to ascertain how long after the onset of symptoms the patient had consulted a physician, and, where sufficient data were given, the delay averaged 5.3 months (sixty reporting shortly after onset). Nine patients admitted having been treated over considerable periods of time by chiropractors or cultists. It was impossible to ascertain from more than one-third of our histories how much time elapsed between the time the patient first saw a doctor and the date of operation, but the average for each group where sufficient data were given was a little more than eight

CARCINOMA OF THE STOMACH

months. It was surprising and disappointing to find that this figure did not vary 0.1 month for any group.

Symptoms.—According to the histories, the duration of symptoms varied from a few days to many years. The exact date of onset was indefinite in many cases as patients frequently could not differentiate between chronic bowel disturbances or “indigestion,” and the onset of their immediate symptoms. There seem, however, to be two types of history, a short and a long. The short history varies from three years to a few days, and, while the patients have frequently been treated for ulcer, the histories are never altogether typical. Almost 12 per cent. of patients gave a very good ulcer history preceding the present trouble by many years. One of these patients had had a gastroenterostomy done by Doctor Bevan twelve years before, and, at operation, an old healed ulcer was found remote from the site of the cancer. Although there is a great deal of difference of opinion as to the etiological importance of ulcer in cancer of the stomach, a histological study of our resected cases reveals only 6 per cent., which were definitely on an old ulcer base. This is in accord with the figures of Hartmann,³ Cuneo and Duval, Karsner, and most pathologists.

The most common symptom for the entire group is *pain*, which varied from mild epigastric distress to acute, severe pain. This symptom was complained of in 302 out of 400 (75 per cent.). It was the first symptom complained of by more than one-half the patients. Next in frequency came loss of weight, although only seventeen mentioned it as the first symptom. This weight loss varied from 5 to 115 pounds, the average being most marked in the group of patients who had only exploratory operations, thirty-two pounds, and the least in the resection group, twenty-three pounds. Only four patients in the entire series reported a gain in weight. The next most common symptoms in the order of frequency were vomiting, weakness, loss of appetite, fullness, indigestion, *etc.*, as shown in Table I. It is interesting to note that twenty-seven had definite knowledge of a tumor mass.

The *family history* was negative in the majority of cases, although a definite history of carcinoma in the family was obtained from forty-five patients (11 per cent.). Three brothers in one family died of cancer of the stomach, one patient's father died of carcinoma of the pylorus while his mother had carcinoma of the œsophagus. Were it not for a tendency among medical men in outspoken cancer cases to avoid inquiry into the family history, more carcinoma families might have been discovered.

On examination emaciation was the most common finding although it was entirely absent in 30 per cent. of the resected cases. A definite palpable tumor mass was found 104 times among the unoperated cases (50 per cent.), thirty times among the explorations (62.5 per cent.), fifty times among the gastroenterostomies (67 per cent.), and thirty times in the resections (52 per cent.)—not a great difference. It is my impression that a tumor might have been found in a higher percentage of cases had more of the examinations been made under the fluoroscope, a suspicious sense of resistance often

DOCTOR GATEWOOD GATEWOOD

TABLE I
Order of Complaints

Symptom	1	2	3	4	5	Totals*
Pain.....	212	41	25	21	5	302
Loss of weight.....	17	89	89	44	21	282
Vomiting.....	22	65	34	35	15	177
Weakness.....	34	35	42	30	18	165
Loss of appetite.....	25	32	37	14	6	123
Fullness.....	37	27	14	6	3	90
Indigestion.....	26	20	5	1	1	56
Anæmia.....	1	8	5	6	8	50
Tarry stools.....	1	6	11	4	4	36
Diarrhœa.....	13	8	6	4	2	35
Difficulty in swallowing.....	14	7	7	4	1	33
Hæmorrhage.....	1	6	11	5	6	33
Knowledge of tumor mass....	6	6	3	4	5	27
Regurgitation.....	4	10	4	2	1	21
Jaundice.....	2	2	1	3	2	11

* The figures in the five columns represent the order in which the patients gave the more common symptoms. The total numbers of *all* patients mentioning the symptoms are listed in the last column. Naturally, many patients had more than five complaints.

becoming definite mass when felt in conjunction with a visible defect. Ascites was found in thirty cases and reported as probable in four others. Virchow's glands were noted in eight cases (2 per cent.). Obviously the presence of Virchow's glands excludes the possibility of radical resection. Although œdema and ascites are usually late, they may result from anæmia and not from implant metastases, as shown in one patient who has been well for five years after resection.

The laboratory findings revealed occult blood in the stools in 95 per cent. of all cases, and in the stomach contents in approximately the same percentage of the cases in which examinations were made. Seventy-three per cent. had no free hydrochloric acid, 16 per cent. had a normal acidity, and the rest were hypoacid. Only one patient had hyperacidity. The percentage of cases with free hydrochloric acid is shown in Table II. It will be noted that the percentage is highest in resected cases, but almost as high in those considered inoperable.

TABLE II
Acidity in Stomach Contents

Type of Operation	Free Acid Present	No Free Acid	Percentage of Cases with Free HCl
Resections.....	16	35	31.4
Gastroenterostomy.....	27	45	27.5
Explorations.....	8	31	20.5
Unoperated.....	41	99	29.3

Lactic acid was reported as negative in seven of the achlorhydrias, but, according to Dodds and Robertson,⁴ this was probably due to inaccurate examination, as they feel that lactic acid is almost always present in the

CARCINOMA OF THE STOMACH

absence of free hydrochloric acid and show that it is not caused by tumor formation. Polland and Bloomfield⁵ believe that the presence or absence of free hydrochloric acid depends upon the amount of gastritis present, bearing out the suggestion of Mathieu, made in 1889. We have made microscopical examinations of remote portions of all of our resected stomachs and have found a certain amount of gastritis almost invariably present. The degree did not seem to bear any relationship to the presence or absence of hydrochloric acid. Comparing cases with obstruction with those which had none, retention of gastric contents did not seem to influence the acidity. Although the presence of pus- and tumor-cells is of diagnostic importance and should always be searched for as well as long bacilli, they were reported in a very small percentage of this series.

The importance of X-ray examination cannot be over-emphasized, the accuracy of diagnosis in all except the occasional ulcer-carcinoma being nearly 100 per cent. The ability of the X-ray department to determine operability is not quite so good and whenever there is a question of doubt, the patient should be given the benefit of exploration. At least three of the fifty-eight resections were thought to be non-resectable on X-ray examination.

The *operative treatment* consisted in the procedures shown in Table III.

TABLE III
Types of Operation

Operations	Male	Female	Total	Per Cent.	Hospital Mortality (Per Cent.)
Explorations.....	32	16	48	23	32.6
Gastroenterostomies.....	68	17	85	40.9	25.9
Resections.....	45	13	58	27.8	32.6
Gastrostomies and jejunostomies...	8	7	15	7.2	80
Ileosigmoidostomy.....	1		1	.5	100
Closure of perforation.....	1		1	.5	100
Totals.....	155	53	208	100	

The hospital mortality has been unusually high, but it should be noted that some of these patients remained in the hospital for several weeks after operation. The hospital mortality from gastroenterostomy is almost as high as from resection. Anterior gastroenterostomy with or without entero-anastomosis was made in thirty-six cases and posterior gastroenterostomy was made in forty-nine.

The Billroth II, or some type of end-to-side anastomosis, as the Balfour, or Polya, has been used in all of the resections except one in which the Billroth I was performed. Most of the lesions were extensive, making resection of the colon necessary in one case and part of the pancreas in three. Palliative operations of this type carry a high mortality but one of these patients is well almost ten years later and several palliative resections lived more than three years.

Post-operative Results.—The follow-up of this series has been exceptionally difficult as many of these patients have been dead over eight years, but the diligent efforts of my secretary and myself have been rewarded by reports upon 100 per cent. of the resections, 98 per cent. of the gastroenterostomies and 95 per cent. of the explorations. All of the patients who were explored or upon whom gastroenterostomy was performed are dead. The average length of life following exploration was 6.1 months. After gastroenterostomy, patients lived an average of 8.75 months, or only 2.65 months longer. Following resection, the patients who left the hospital have lived an average of four years and nine months. Those who are alive have lived an average of six and one-half years. The following table reveals that 46.1 per cent. lived over three years, and 36 per cent. are alive at the end of five years, one patient having just passed the twelve-year mark. Four patients died of intercurrent disease, one five years later following cholecystectomy, with no evidence of metastases at autopsy; one, one year later, of a perinephritic abscess without evidence of recurrence (autopsy); one, following prostatectomy four years later (no history of recurrence, but no autopsy); and one of cerebral hæmorrhage which may have been the result of a brain metastasis (no autopsy). (Table IV.)

TABLE IV

Post-Operative Statistics in Gastric Resections for Carcinoma from January 1, 1920, to December 31, 1929

Type of Carcinoma	Total Cases	Subsequent Deaths			Living		
		Under 3 yrs. (in mos.)	3-5 yrs.	5 yrs. plus	Under 3 yrs.	3-5 yrs.	5 yrs. plus
Adeno-carcinoma . .	22	16, 16, 12, 23, 32, 12, 6, 17, 30*		5 5 and 2 mos.†	2 and 10 mos.		8, 5, 10, 12
Papillary adeno-carcinoma	9	4, 12‡		8½			7, 8
Adeno-scirrhous	6	3	4§		2½	3 and 8 mos.	
Scirrhous	15	15, 28, 19, 19, 7	4	5½ 6 and 2 mos.			
Colloid	2	18				4½	
Ulcer-carcinoma . . .	3			5			9, 5
Linitis plastica . . .	1	24					
Totals	58	19	2	6	2	2	8

* Influenza.

† Cholecystectomy.

‡ Perinephritic abscess.

§ Prostatectomy.

It has been impossible to correlate the pathological findings with the ultimate results except in a general way. The prognosis was worst in the

CARCINOMA OF THE STOMACH

scirrhous type of lesion, which agrees with the findings of M. Persson⁶ and others. It is better in the adeno-carcinoma and, as one might expect, best in the carcinoma on an ulcer base. Some of the more extensive adeno-carcinomas (with glandular metastases) have been symptom-free more than five years.

SUMMARY

Four hundred and seventeen patients with carcinoma of the stomach were admitted to the Presbyterian Hospital between January 1, 1920, and December 31, 1929.

Fifty per cent. of these patients were diagnosed as inoperable at time of admission to the hospital.

Of the operations performed, 23 per cent. were exploratory only, 7 per cent. were palliative for relief of starvation (gastrostomy and jejunostomy), 41 per cent. were gastroenterostomies and 28 per cent. were gastric resections.

The hospital mortality for gastroenterostomy was 26 per cent., and for gastric resections was 32.6 per cent.

A careful follow-up has given the ultimate results in 95 per cent. of exploratory operations, 98 per cent. of gastroenterostomies and 100 per cent. of the gastric resections. The average post-operative length of life after exploration was found to be 6.1 months, after gastroenterostomy, 8.75 months, after resection four years and nine months. The patients living at the present time have survived an average of six and one-half years. After resection 46 per cent. of the patients leaving the hospital lived three years or more. Thirty-six per cent. survived over five years, but of these, five subsequently died of carcinoma. Five patients are living eight or more years after resection, and a few have died without evidence of recurrence.

Free hydrochloric acid was present in 20 to 30 per cent. of cases, without striking difference between the operable and inoperable cases. Diffuse gastritis is present in most cases and does not seem to explain the achlorhydria.

More than a year elapsed between the first symptom and operation in many of the operated cases in this series. If we are to improve our outlook in this important group of cases, barring the discovery of some real cancer cure, our attention must be directed toward earlier diagnosis, better preparation and better technic.

BIBLIOGRAPHY

- ¹ Gatewood: Transactions Western Surg. Assn., 1930, 349.
- ² Ransom, H. K., and Collier, F. A.: Carcinoma of the Stomach. Jour. Mich. State Med. Soc., vol. xxxi, p. 87, February, 1932.
- ³ Hartmann: Bull. et Mém. Soc. Nat. de Chir., vol. liv, pp. 263, 423, 455, 1928.
- ⁴ Dodds, E. C., and Robertson, J. D.: Quart. Jour. Med., vol. xxiii, p. 175, 1930.
- ⁵ Pollard, W. Scott, and Bloomfield, A. L.: Bull. Johns Hopkins Hosp., vol. xlvi, p. 307, 1930.
- ⁶ Persson, M.: ANNALS OF SURGERY, vol. lxxxvi, p. 321, 1927.

DISCUSSION.—DR. J. SHELTON HORSLEY (Richmond, Va.) remarked upon the excellent statistics of Doctor Gatewood of permanent cures of cancer of the stomach. He had been much impressed by the statistics published by Saltzstein and Sandweiss,

and by Dr. Margaret Warwick a few years ago. These were all from necropsies. Saltzstein and Sandweiss published the results of 365 necropsies in cancer of the stomach in Detroit. In these 365 cases, only 7.7 per cent. had had an excision of the cancer. Doctor Warwick's statistics in Minneapolis showed that in 23 per cent. of the necropsies in cancer of the stomach there were no metastases outside of the stomach. It seems probable that if 23 per cent. of patients dying from cancer of the stomach have the cancer still limited to the stomach, if the patients were operated upon a few months before death the percentage of cases of cancer limited to the stomach would be even larger. Apparently patients with cancer of the stomach are not receiving a fair deal. While a few of this 23 per cent. of the patients who died with cancer limited to the stomach have cancer in the cardiac portion of the stomach which is inaccessible, it is well known that most cancers of the stomach are in the body or the pyloric end.

If the surgeon could only get these cases a little earlier the percentage of cures after resection would undoubtedly be larger, but even with patients in whom the growth appears to be extensive an exploratory operation sometimes shows that the cancer is resectable even though the röntgenological report indicates otherwise. The cancer of the stomach may be of histologically low grade of malignancy, requiring only a slim margin of apparently healthy tissue for a satisfactory resection.

Whenever it is possible to do a partial gastrectomy, it should be done instead of gastroenterostomy. Gastroenterostomy, which merely short-circuits the food and leaves behind a mass of diseased and often necrotic tissue, does but little good. Partial gastrectomy carefully done, possibly under local anæsthesia, followed by a transfusion of blood, should carry but little higher mortality rate than a gastroenterostomy and gives much greater relief, even if it cannot cure.

DR. DONALD C. BALFOUR (Rochester, Minn.) was in agreement with Doctor Gatewood on various points, especially the symptomatology and variation in the course of the disease. Some slowly develop carcinoma; such as the type of case in which the patient comes with an achlorhydria, anæmia and negative X-ray and as one follows it along one suspects carcinoma, and suddenly the X-ray reports an inoperable cancer of the stomach. It is interesting to think what is going on in these patients with secretory disturbance and anæmia. Looking up our figures on operability we found that 50 per cent. of the patients with cancer of the stomach come to operation and in about one in five of the cases diagnosed is resection possible.

Doctor Horsley emphasized (it cannot be over-emphasized) that X-ray is valuable in spotting a lesion of the stomach, but possibly we depend a little too much on the X-ray as showing the extent of the lesion and what can be done with it in a surgical way. All patients with carcinoma of the stomach should be explored unless metastases or age contra-indicate.

What Doctor Horsley said about extensive resection is true because some of the patients who were cured, where the nodes were not removed, were apparently incurable because of extensive lymph-node involvement.

In cases of cancer of the stomach the family history of cancer was given in 16 per cent.; of gross hæmorrhage in 12 per cent.; of an average value of hemoglobin of 60 per cent.; of obstruction in 30 per cent.; and 50 per cent. had gastric acidity with normal hydrochloric acid or above.

The classification of Doctor Broders in the patients who had ten-year cures shows 55 per cent. of grades I and II; 35 per cent. of grade III; 10 per cent. of grade IV. In all cases of resection the classification was just the reverse in that 20 per cent. were of grade I and II; 35 per cent. of grade III, and 44 per cent. of grade IV.

CALCIUM CARBONATE GALL-STONES AND THEIR EXPERIMENTAL PRODUCTION

By DALLAS B. PHEMISTER, M.D., LOIS DAY, M.D.

AND

A. BAIRD HASTINGS, PH.D.

OF CHICAGO, ILL.

FROM THE DEPARTMENT OF SURGERY AND THE LASKER FOUNDATION FOR MEDICAL RESEARCH THE UNIVERSITY OF CHICAGO

CALCIUM carbonate as a separate deposit in the lumen of the gall-bladder in the form of either a white stone or paste and casting dense shadows in röntgenograms was reported in eight cases to the American Surgical Association in 1931 by Plemister, Rewbridge and Rudisill. In all instances the cystic duct was obstructed. The obstruction was produced by an ordinary gall-stone of the cholesterol or cholesterol-pigment variety except in one case where it was due to carcinoma. The order of development was as follows: Cholecystitis and cholesterol or cholesterol-pigment stone formation, engagement of a stone in the cystic duct with long-standing obstruction, low-grade chronic inflammation, reduction in the amount of fluid contained in the gall-bladder and deposition of calcium carbonate in it. In long-standing cases the calcium carbonate formed a large, white, soft stone. When ordinary cholesterol-pigment stones were present they were either incorporated within or partially coated by the calcium carbonate. In some cases sufficient calcium carbonate had been deposited on the stone in the cystic duct and particularly on its gall-bladder side to make it recognizable in röntgenograms along with the calcium carbonate deposit in the gall-bladder. The gall-bladders were smaller than normal and cholecystography revealed non-visualization with tetiothalein.

Of forty-eight consecutive cases operated on for gall-stones since that report, eleven, or 22.9 per cent., were found to have obstruction of the cystic duct by a stone. Six of these, or 12½ per cent., had mild chronic cholecystitis with a separate deposit of calcium carbonate in the gall-bladder. In one case the deposit occurred as a mucous suspension, in four as a semi-solid paste and in one as a solid in the form of coarse sand (Kalkgries). The remaining lumen of the gall-bladder was occupied in five cases by a few cubic centimetres of thick mucus. In one case there was a slightly turbid serous fluid which was obtained for chemical analysis. The remaining five cases with cystic-duct obstruction but without calcium carbonate precipitation showed more marked inflammation of the gall-bladder with serous exudation and the ordinary picture of hydrops.

Experimental work is reported in which, after cystic-duct ligation, a pure calcium carbonate deposit was obtained in the lumen of the gall-bladder of the dog and calcareous deposits too small for accurate chemical analysis within the gall-bladders of rabbits.

The six cases are grouped as, first, those in which multiple cholesterol-pigment stones, and second, those in which a single cholesterol stone, in the gall-bladder, preceded the development of cystic-duct obstruction and the deposition of the calcium carbonate. They are arranged in each group according to the apparent age of the deposit, beginning with the earliest.



FIG 1—(Case I) Röntgenogram of gall bladder before tetiothalein administration

CASE REPORTS

CASE I—H F, male, aged forty-five years, had had attacks of gas pains in the abdomen for seventeen years. Appendectomy sixteen years ago with no relief. Loose and frequent stools at intervals. During the past two years has had at irregular intervals attacks of epigastric pain, at times associated with nausea and vomiting, lasting from a few minutes to three or four hours. Has never had fever or jaundice with the attacks. Physical examination revealed a healthy-appearing man and regional examination was essentially negative. A röntgenogram (Fig. 1) showed a radio-opaque shadow

GALL-STONES AND THEIR PRODUCTION

in the gall-bladder region which was smaller and narrower than a normal gall-bladder. Scattered throughout it were numerous radio-translucent areas with ring-shaped densities



FIG. 2.



a



b



c

FIG. 3.

FIG. 2.—(Case I.) Röntgenogram of excised gall-bladder.
FIG. 3.—(Case I.) Photograph of (a) gall-bladder; (b) mucus which contained calcium carbonate; (c) gall-stones.

about their periphery. Cholecystography revealed non-visualization of the gall-bladder with dye and no change in the shadow in the gall-bladder region.

Operation revealed a gall-bladder smaller than normal, free from adhesions and

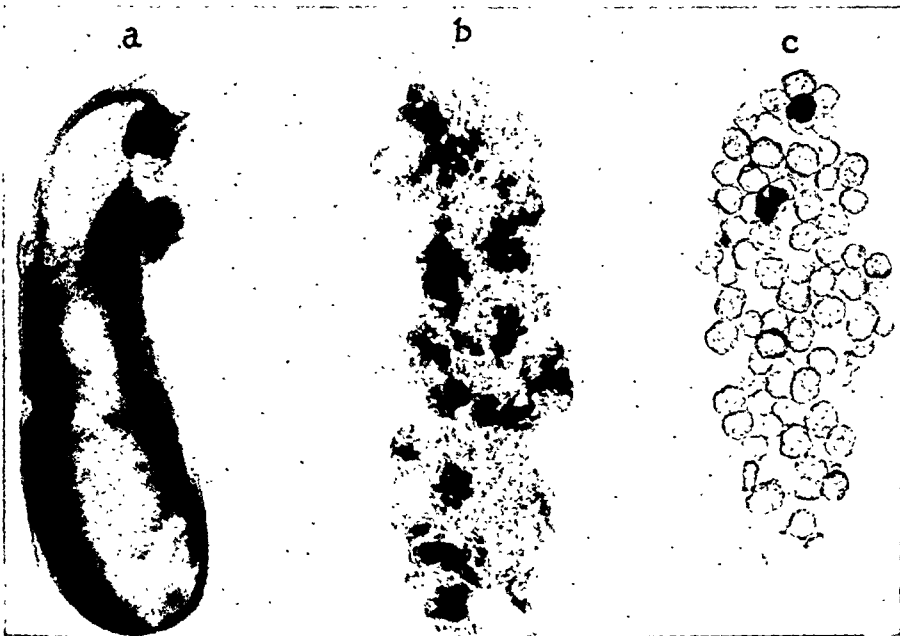


FIG. 4.—(Case I.) Röntgenogram of specimens shown in Fig. 3. (b) Calcium carbonate shadows in the mucus.

containing many stones. There was also a stone in the cystic duct. Cholecystectomy. A röntgenogram of the specimen (Fig. 2) showed numerous radio-translucent shadows, some of which had a narrow rim about their periphery. Between the radio-translucent

areas there are diffuse radio-opaque shadows. Section of the gall-bladder showed it to be filled with a dark green, opaque, thick, mucous fluid containing many spherical stones, and there were two stones in the cystic duct. The gall-bladder wall was slightly thickened and its mucosa appeared to be intact. Fig. 3 shows separately the interior of the gall-bladder, its mucous content, throughout which was distributed a grayish, opaque, soft substance, and the gall-stones. Fig. 4 shows a rontgenogram of these structures. The mucous mass casts a heavy irregular dense shadow and some of the gall-stones

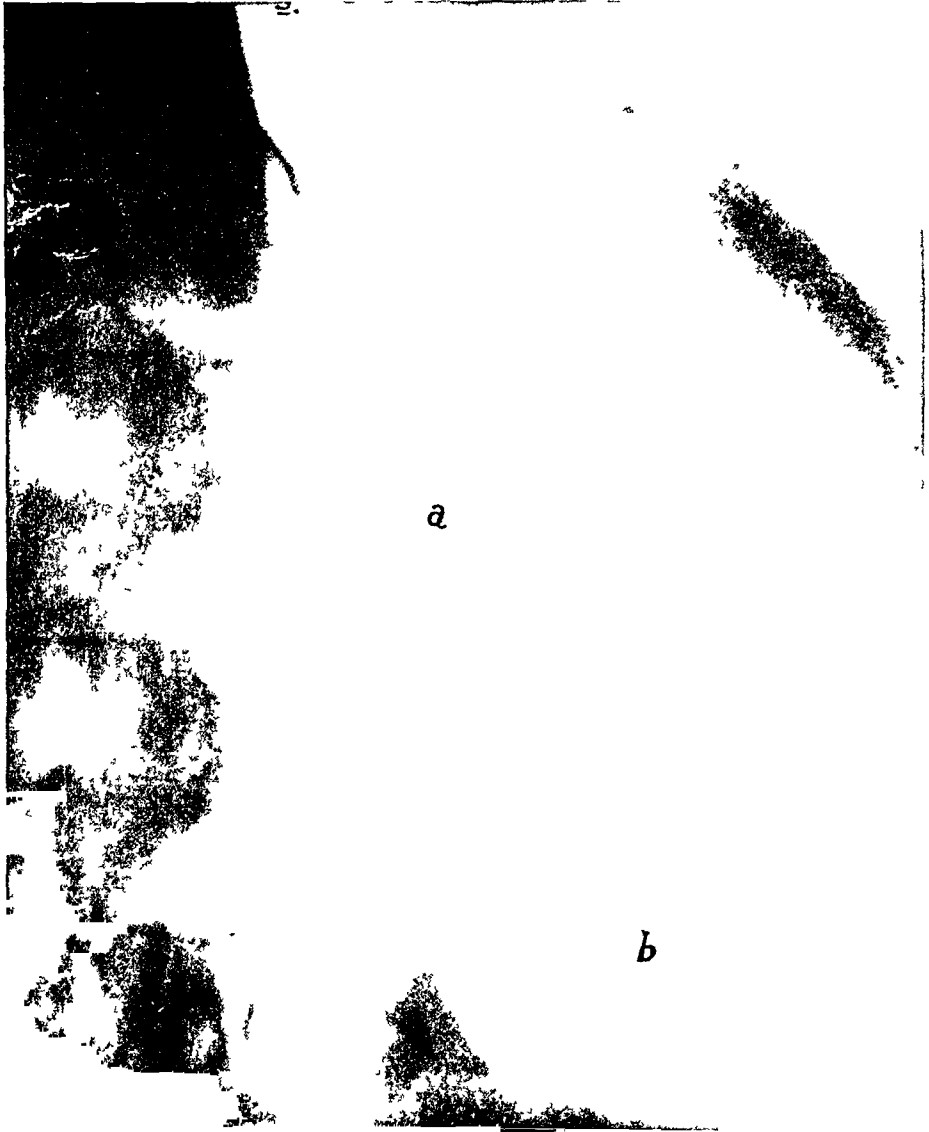


Fig 5 —(Case II) Röntgenogram showing shadow in region of cystic duct (a) and gall bladder (b)

show radio-opaque rings about their surfaces. A chemical analysis of the thick mucous material revealed calcium 14.5 milligrams, phosphorus 1.0 milligrams, and CO_2 14.1 cubic centimetres per 100 milligrams dry exudate. The content was not sufficiently solid for an accurate calculation of the percentages of calcium carbonate and calcium phosphate present. Cholesterol and bile pigment present.

This represents an early stage in deposition of calcium carbonate in the gall-bladder. The mucous was stained with bile which indicated either that the calcium had been deposited before the bile pigments had been absorbed

GALL-STONES AND THEIR PRODUCTION

or that a small amount of bile had continued to enter past the stones in the duct. The calcium had not yet begun to collect into soft solid masses as in the older cases.

CASE II.—I. T., male, aged thirty-six years, had had frequent attacks of pain in the right upper quadrant of the abdomen during the past five years, lasting usually for a few hours. They might come as often as twice a week, but might not recur for ten

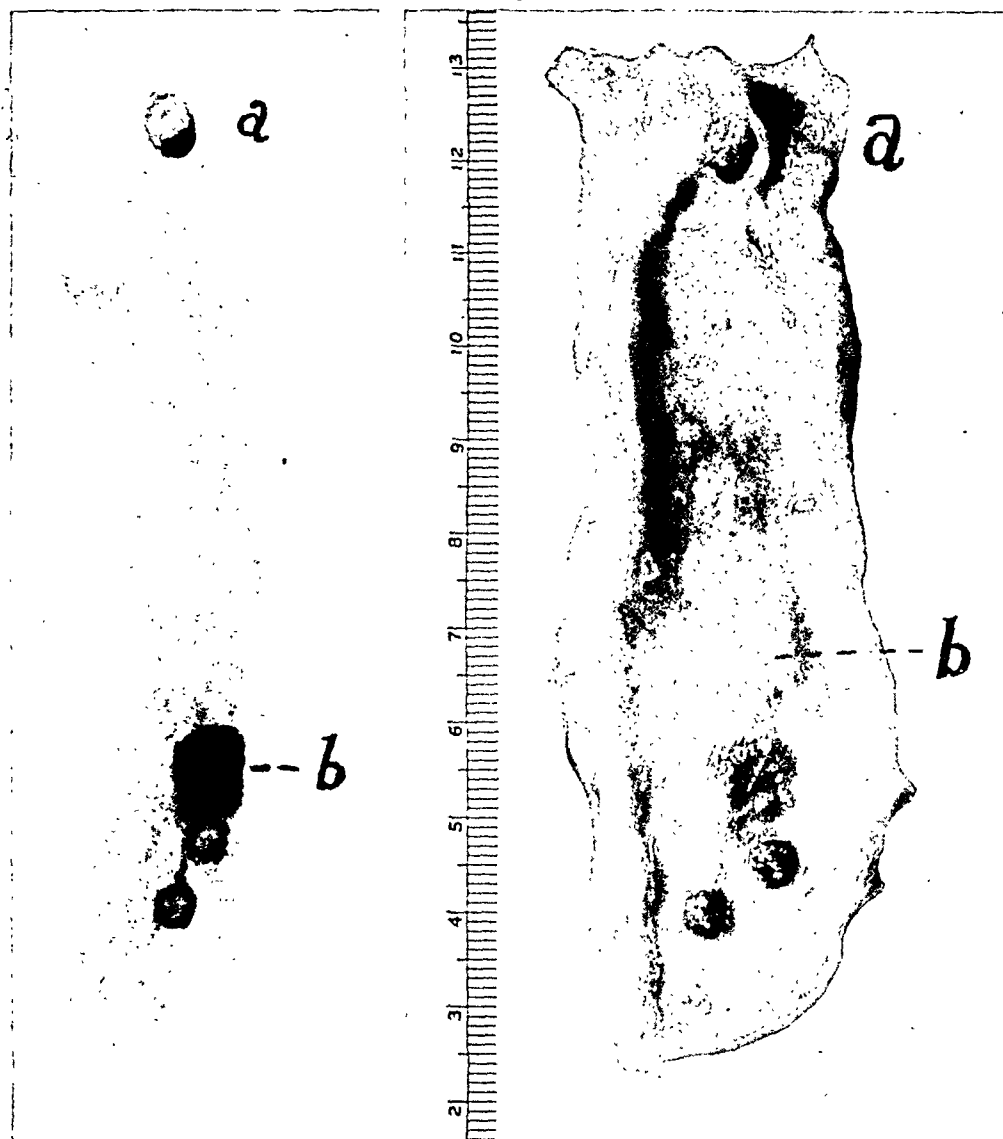


FIG. 6.

FIG. 7.

FIG. 6.—(Case II.) Röntgenogram of specimen showing shadow of stone in cystic duct (a) and of calcium-carbonate paste (b), as well as ring shadows of calcium on two cholesterol pigment stones.

FIG. 7.—(Case II.) Gall-bladder opened exposing stone in cystic duct (a) and calcium-carbonate paste buried in mucus (b). Cholesterol-pigment stones are distal to it.

weeks, with complete relief during the intervals. Vomiting had been frequent, but the attacks were short and not accompanied by fever or jaundice.

Physical examination revealed a healthy-appearing, well-nourished male. Regional examination essentially negative. No masses nor tenderness in gall-bladder region. A röntgenogram (Fig. 5) revealed two radio-opaque shadows in the right upper quadrant, a small one in the region of the cystic duct and a larger one in the region of the gall-bladder. Cholecystography showed no change in the films taken after intravenous administration of tetiothalein. At operation the gall-bladder was found markedly collapsed, as if it had been emptied by aspiration. There was a stone in the first portion

of the cystic duct and there were small stones in the gall-bladder. Findings were otherwise negative. Cholecystectomy including portion of cystic duct containing stone. A rontgenogram of the specimen (Fig. 6) revealed ring shadows on the stones in the gall-bladder and a ring shadow broadest on the gall-bladder side of the stone in the

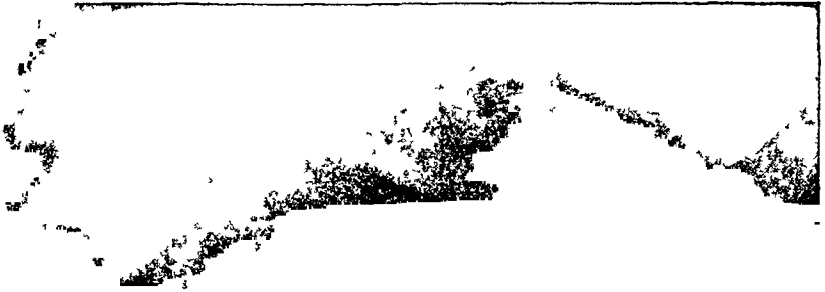


FIG 8—(Case III) Gall bladder shadow before administration of dye.

cystic duct. There was also a separate uniformly dense oval shadow in the gall-bladder.

Pathology.—The gall-bladder (Fig. 7) was nine centimetres long and collapsed. On section its wall was slightly thickened and its lumen contained only a few cubic centimetres of a slightly bile-stained thick mucus in which were three rough brown stones and a grayish white, slimy mass about one centimetre in diameter, of the consist-

GALL-STONES AND THEIR PRODUCTION

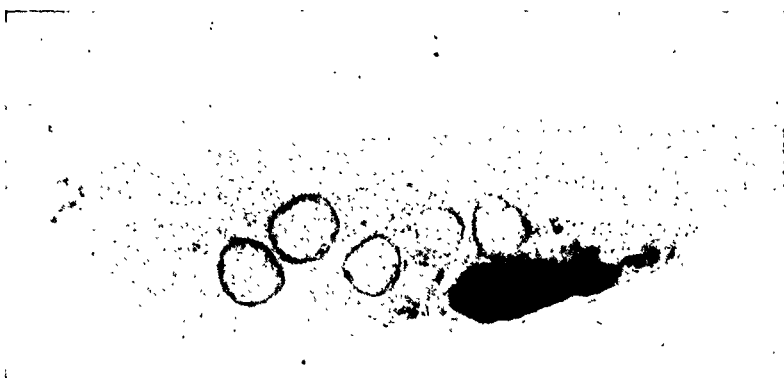


FIG. 9.—(Case III.) Röntgenogram of specimen showing shadows of ring stones and of calcium carbonate which had changed in shape from that in Fig. 8.



FIG. 10.—(Case III.) Photograph of (a) gall-bladder, (b) mucous content with oval gray mass of calcium-carbonate paste and (c) gall-stones.

ency of paste. A stone was tightly embedded in the cystic duct. It had a lighter brown color on the gall-bladder side than on the side away from it.

Microscopical examination showed mucosa intact and villi crowded together. There was a slight amount of round-cell infiltration of the wall and extremely little fibrosis.

Cultures on Rosenow's media of the mucus and wall remained sterile. Chemical analysis of the paste-like mass gave: calcium carbonate, 64.3 per cent.; calcium phosphate, 0.7 per cent.; the rest was organic matter. Bile pigment was present in the mucus by the nitric-acid test and cholesterol was absent.

The presence of calcium carbonate X-ray densities incorporated in ring form in the periphery of the cholesterol-pigment stones suggests that the calcium carbonate was laid down in the presence of obstruction and the growth of the deposit into a thick layer on the gall-bladder side of the stone in the cystic duct renders this assumption

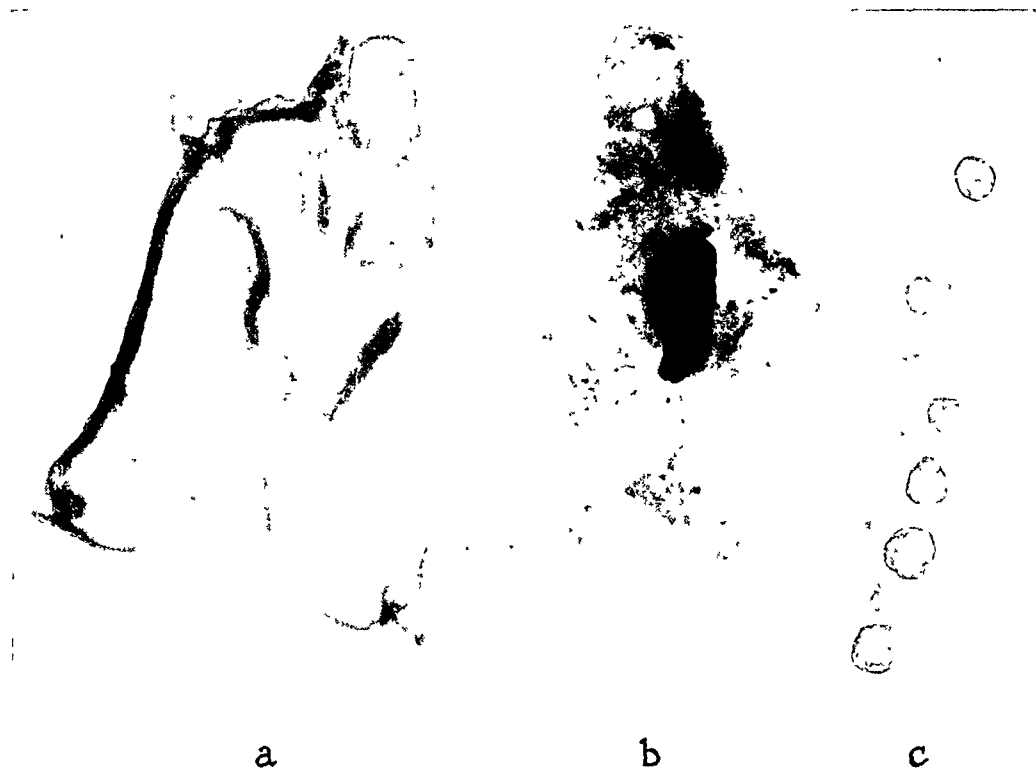


FIG. 11.—(Case III.) Röntgenogram of specimens in Fig. 10; (b) dense shadow of mass of calcium carbonate.

almost a certainty. It is known, as reported by Romang, that the radio-opaque shadows cast by gall-stones are due practically entirely to calcium carbonate, since only small amounts of calcium phosphate are ever present and the calcium-pigment salts contain so little calcium that their radio-opacity is but slightly greater than that of water.

CASE III.—C. O., male, aged sixty-one years, had had attacks of pain in epigastrium and right upper quadrant at irregular intervals for seven years, occasionally associated with nausea and vomiting. Within the past eleven months he had had three attacks that were followed by jaundice. The last one occurred two months ago and slight jaundice lasted for one month. Much epigastric distress during the period. Physical examination was essentially negative aside from increased resistance in gall-bladder region. No jaundice. No bile in urine. Patient brought a röntgenogram taken seven and one-half months previously which revealed a small pear-shaped opaque shadow in gall-bladder region in which were circular radio-translucent shadows. (Fig. 8.) Another radiogram was made which revealed a slightly smaller but more dense, oval,

GALL-STONES AND THEIR PRODUCTION

radio-opaque shadow in the same region. Cholecystography showed no shadow of dye in the gall-bladder region. At operation the gall-bladder was found to be much smaller than normal, and flaccid. Its wall was somewhat thickened and several stones were palpated. A stone was tightly impacted in the cystic duct. Cholecystectomy. A röntgenogram of the gall-bladder (Fig. 9) revealed several radio-translucent circular shadows with dense rings or specks about the periphery. In addition there was an oval radio-opaque shadow two centimetres long and separate radio-opaque flecks in its



FIG. 12.—(Case IV.) Röntgenogram of gall-bladder before tetiothalein administration.

vicinity. On section the gall-bladder contained a thick, light green mucous fluid. Imbedded in it were fourteen mulberry stones of various sizes and grayish to brown in color. There was one oval, paste-like, grayish mass two centimetres in length and numerous grayish flecks seen in the mucus. (Fig. 10.) A röntgenogram of the gall-bladder, mucous content and stones (Fig. 11) shows faint rings about some of the gallstones and a dense radio-opaque shadow cast by the paste in the mucus. Cultures on blood agar plates and Rosenow's media remained sterile. Microscopical examination of the gall-bladder revealed a small amount of fibrosis and moderate infiltration of the wall with lymphocytes. The mucosa and villi were intact but somewhat flattened. Chemical analysis of the paste revealed: calcium carbonate, 81.3 per cent., calcium

phosphate, 0.5 per cent.; the rest organic matter. The mucus showed bile pigment present and cholesterol absent.

CASE IV.—E. J., female, aged twenty-nine years. During the past four months the patient had had about ten attacks of pain in the epigastrium, sometimes radiating to the right scapular region, lasting from a few minutes to six hours. Vomiting in about one-half of the attacks. No fever or jaundice. Past history negative aside from childhood diseases.

Physical examination revealed a well-developed white woman. Regional examination essentially negative aside from slight tenderness in the right upper quadrant of abdomen. No mass in gall-bladder region. A röntgenogram (Fig. 12) revealed small,

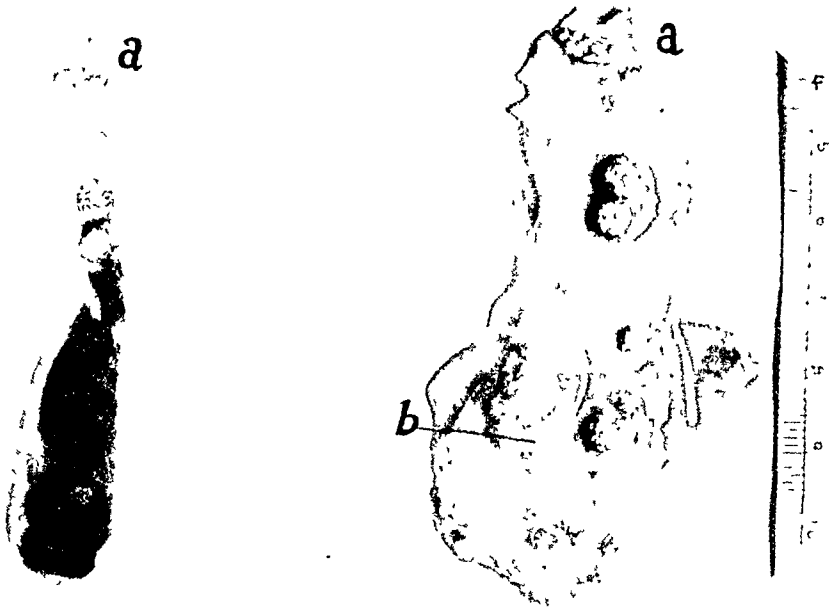


FIG. 13.

FIG. 14.

FIG. 13.—(Case IV.) Röntgenogram of specimen; (a) is crushed stone in cystic duct.

FIG. 14.—(Case IV.) Gall-bladder opened showing its content of stones, mucus and calcium carbonate; (a) is crushed stone in cystic duct, and (b) the largest mass of calcium carbonate incorporating cholesterol-pigment stones.

dense, oval, radio-opaque shadows along the course of the gall-bladder. The largest one at the lower end incorporated a circular radio-translucent area. Cholecystography showed no change in X-ray appearance after dye. A diagnosis was made of cholelithiasis, calculous obstruction of cystic duct and calcium carbonate deposit in gall-bladder about stones. At operation the gall-bladder was small, flaccid, slightly thickened and contained small stones. There was a stone in the cystic duct. Cholecystectomy.

A röntgenogram of the specimen (Fig. 13) showed a heavy, radio-opaque shadow about or incorporating radio-translucent stone shadows with speckled dense surfaces. The gall-bladder was partly collapsed and measured seven centimetres in length. Its wall was slightly thickened. On section it contained a few cubic centimetres of a dark green, stringy, thick mucus. There were eight brown gall-stones, varying from one-third to two-thirds centimetre in diameter, in the gall-bladder, and one crushed stone in the cystic duct. In addition there were three oval, putty-like, gray masses in the gall-bladder, the largest being two centimetres long and incorporating four small brown stones. (Fig. 14.) Cholesterol and bile pigment were present in the mucus. Cultures

GALL-STONES AND THEIR PRODUCTION

of the bile revealed no growth on blood-agar plates, Rosenow's media and plain broth in eight days.

Microscopical examination of the gall-bladder wall revealed the mucosa intact and very slight fibrosis and scattered lymphocytic infiltration of the muscularis and serosa.

The paste was removed from the specimen but was lost so that no chemical analysis was obtained, but its likeness to the other cases is so great that its nature can scarcely be questioned.

CASE V.—J. R., male, aged thirty-seven years, complained of attacks of fullness of the stomach, belching and epigastric distress for ten years and of occasional sharp attacks of epigastric pain lasting from a few minutes to hours during the past two years.



FIG. 15.—(Case V.) Röntgenogram showing radio-opaque shadow in region of cystic duct (a) and gall-bladder (b).

He has never been laid up with the attacks and there has been no accompanying jaundice or fever. Physical examination was essentially negative. There was no mass, tenderness or rigidity in the gall-bladder region. A röntgenogram (Fig. 15) revealed a dense oval shadow one and one-half centimetres long, lying below the right twelfth rib and a faint shadow in the region of the cystic duct. Cholecystography showed non-visualization of the gall-bladder. The diagnosis was made of calculous obstruction of cystic duct and calcium carbonate deposit in the gall-bladder.

At operation the gall-bladder was found collapsed and shrunken to about five centimetres in length. A stone was felt in the cystic duct. Cholecystectomy including the portion of the cystic duct containing the stone. A röntgenogram of the specimen (Fig. 16) revealed an oblong, fragmented shadow two centimetres long in the fundus of the

gall-bladder and a spherical shadow in the cystic duct. On section the gall-bladder contained a small amount of dark, thick, mucus and in the fundus an oval mass of gray paste which had been broken up by handling. There was a cholesterol stone in the first portion of the cystic duct with a brown deposit on its surface. (Fig. 17.) Microscopical sections of the wall revealed little fibrosis but areas of round-cell and eosinophilic infiltration of the wall. The epithelial lining and villi were intact. Chemical analysis of the paste in the gall-bladder showed it to contain a very high percentage of calcium and only a trace of phosphorus, but the amount was too small for a determination of the proportions of carbonate and phosphate.

CASE VI—T. T., female, aged thirty-seven years, was admitted to the University of Chicago Clinics September 12, 1930. For three years she had had occasional attacks of pain in the right upper quadrant lasting for a few hours, sometimes accompanied by vomiting. During the past year several attacks of painful and frequent urination which have at times coincided with the abdominal colics.

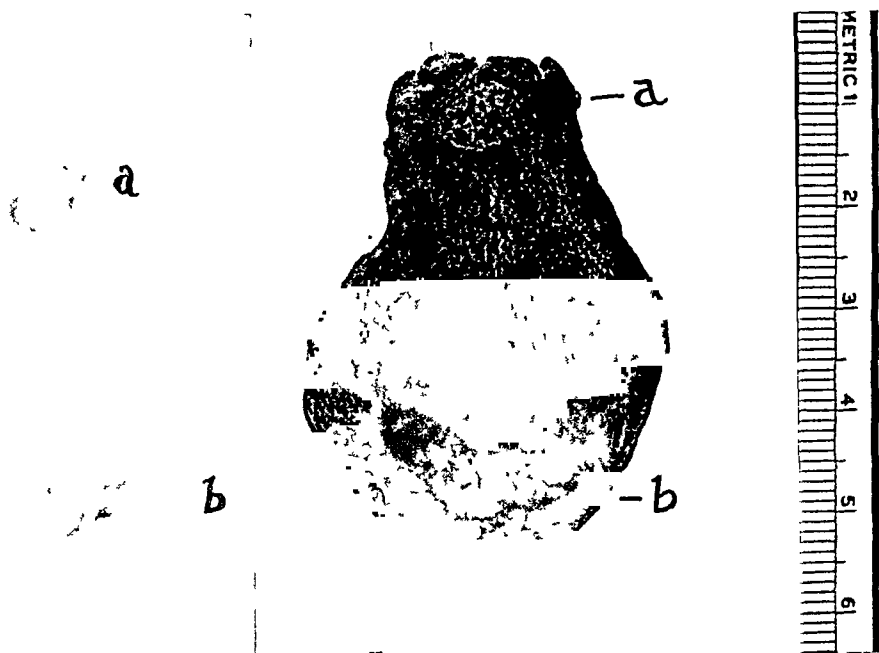


FIG. 16.

FIG. 16—(Case V) Rontgenogram of specimen showing (a) shadow of stone in cystic duct and (b) shadow of mass in gall bladder.

FIG. 17.

FIG. 17.—(Case V) Gall bladder opened showing (a) cystic duct stone and (b) calcium carbonate paste in fundus.

Physical examination revealed a healthy-appearing, obese woman. Regional examination essentially negative aside from tenderness in the gall-bladder region. A rontgenogram (Fig. 18) revealed a circular, hazy, radio-opaque shadow in the gall-bladder region. No change in rontgenographic appearance after intravenous administration of tetiothalein. Urinalysis, cystoscopy and pyelography showed normal urinary tract. *Diagnosis*.—Calcium carbonate gall-stones. Patient refused operation but returned September 30, 1931, with history of a continuation of the same symptomatology and a severe right upper quadrant colic one week before, which had just worn off. Examination essentially negative aside from tenderness in the right upper quadrant. Urine negative. Operation October 2, 1931. The gall-bladder was slightly smaller than normal and distended with fluid. There was a stone in the cystic duct. No adhesions. Cholecystectomy including cystic duct containing stone.

An X-ray of the specimen (Fig. 19) showed an irregular granular dense shadow within the gall-bladder and a crescent-shaped dense shadow on the gall-bladder side of the stone in the cystic duct. Aspiration yielded twenty-five cubic centimetres of fluid which was placed under oil.

GALL-STONES AND THEIR PRODUCTION

On section the gall-bladder wall was moderately thickened. There was a white deposit of dense, sand-like particles within the lumen as shown in Fig. 20. The stone in the cystic duct was about one centimetre in diameter and firmly anchored. It was pure cholesterol, with a thin white deposit on its gall-bladder side. Cultures of the fluid and gall-bladder wall on blood-agar plates and Rosenow's media remained sterile.

Chemical analysis of the sand-like deposit in the gall-bladder showed: Calcium carbonate, 99.4 per cent.; calcium phosphate, a trace; cholesterol and bile pigment, absent. Chemical analysis of the fluid aspirated from gall-bladder and centrifuged yielded calcium, 10.6 milligrams per 100 cubic centimetres; phosphorus, no reaction; CO₂, 11.25 volumes per cent.; pH, 6.82.

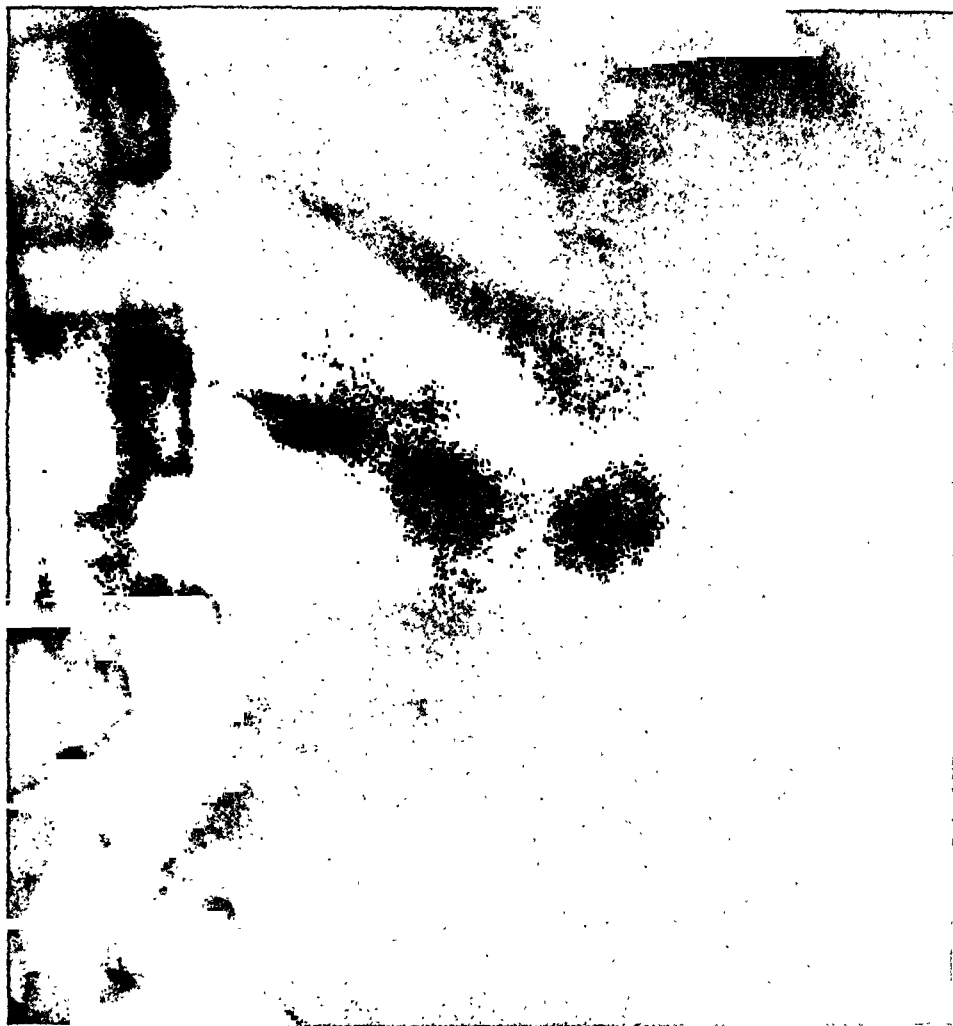


FIG. 18.—(Case VI.) Röntgenogram of gall-bladder before tetiothalein administration.

Animal Experiments.—Attempts were made to produce calcium-carbonate deposits in the gall-bladder by experiments on dogs, rabbits, and sheep.

EXPERIMENTS ON DOGS

Group I.—Ligation of the cystic duct. In none of the sets of experiments was the cystic artery identified and it was undoubtedly ligated along with the duct in many cases. The duct was ligated with silk in three animals, leaving the gall-bladder filled with bile. They were sacrificed in sixty-four, eighty-one, and 222 days. In the sixty-four- and eighty-one-day experiments the gall-bladders were slightly contracted and filled with a brownish-green mucus, the bile pigment not having been entirely absorbed. In the 220-day experiment the gall-bladder was about normal in size and filled with a semi-solid, grayish mucus. There was no evidence of stone nor of paste formation

within the gall-bladders and röntgenogram revealed no shadows suggesting calcium except a few extremely faint areas in the 220-day experiment. The mucus from it showed only 304 milligrams of calcium per 100 grams moist weight.

Group II.—Ligation of the cystic duct with subserous injection of one to two cubic centimetres of a suspension of twenty-four-hour blood-agar plate growth of *Streptococcus viridans*.

In seven experiments the ligated duct opened and bile reentered the gall-bladder so that they were discarded. In eight experiments the duct remained closed and the animals were sacrificed after fifty-five, sixty-nine, eighty-five, ninety-eight, 105, 120, 121, and 220 days.

In the fifty-five-day experiment the gall-bladder was shrunken into a small, fibrosed mass.

In the sixty-nine-day experiment the gall-bladder contained twenty-five cubic centimetres of a dark brown fluid. There were about a dozen pinhead-sized soft masses that

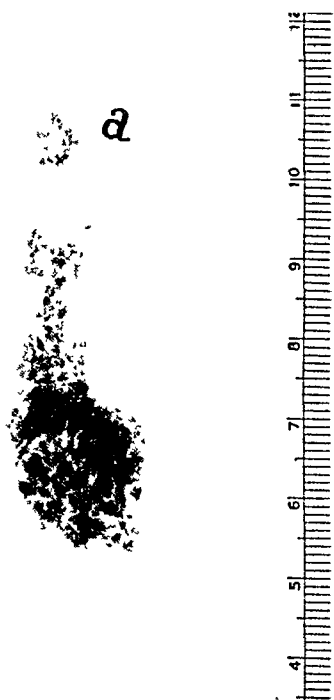


FIG. 19.

FIG. 19.—(Case VI.) Granular dense shadow in gall-bladder and dense deposit on gall-bladder side of stone in cystic duct (a).

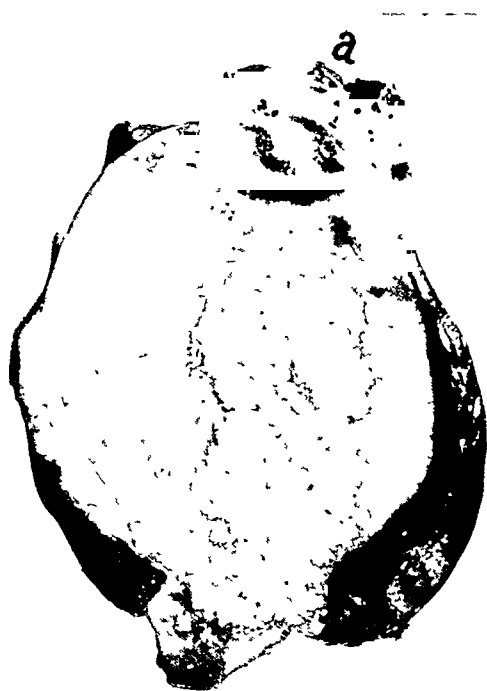


FIG. 20.

FIG. 20.—(Case VI.) Gall-bladder opened showing white sandy deposit of calcium carbonate and exposed cholesterol stone in cystic duct (a).

gave a positive test for bile pigment. The fluid contained calcium, 46.3 milligrams per 100 cubic centimetres; CO₂, sixty-four volumes per cent.; and pH, 6.87. The gall-bladder wall showed almost no change.

The eighty-five-day experiment disclosed a bile-stained, richly mucous fluid in the gall-bladder with little change in the wall. X-rays of the specimen were negative for calcium shadow.

The ninety-eight-day experiment revealed a gall-bladder about one-half the normal size, with a much indurated wall. X-ray of the specimen showed no calcium shadow. On section it was filled with a very thick mucus which was stained dark brown from the old bile.

The 105-day experiment revealed a moderately thickened, slightly contracted gall-bladder which, on X-ray examination, cast no calcium shadow. It contained ten cubic centimetres of a viscid brown fluid, chemical examination of which revealed calcium, 43.6 milligrams per 100 cubic centimetres; phosphorus, a trace; CO₂, 67.1 volumes per

GALL-STONES AND THEIR PRODUCTION

cent.; and pH, 6.67. Gram-positive rods were found in smears of the fluid and anaërobic milk cultures showed stormy fermentation.

The 120-day experiment revealed a shrunken gall-bladder filled with a thick gelatinous fluid which on X-ray examination cast no calcium shadow.

The 121-day experiment revealed a markedly thickened gall-bladder buried between liver lobes and a large inflammatory tumor mass in the adjacent liver. A röntgenogram revealed no calcium shadow. Ten cubic centimetres of turbid white fluid were aspirated. Cultures yielded a growth of *Staphylococcus albus*. There was no solid material in the gall-bladder. Chemical examination of the fluid showed calcium, 11.7 milligrams per 100 cubic centimetres; CO₂, 115 volumes per cent.; and pH, 7.45.

The 220-day experiment showed a moderately shrunken gall-bladder filled with a thick, gelatinous mucus and röntgenograms showed no calcium shadow. Cultures on blood-agar plates remained sterile.

It was apparent that the injection of the streptococci had had little permanent effect. In only one experiment (121 days) did the gall-bladder have the appearance of being extensively infected, but the organism cultured from it was a staphylococcus. In no case did the X-ray cast a shadow suggesting calcium-carbonate deposit and chemical analysis of the fluids in three cases showed the concentration of calcium and carbonate ions much below the level required for calcium-carbonate precipitation.

Group III.—Streptococcus injection of the wall of the gall-bladder. Fourteen experiments were performed in which one to two cubic centimetres of a suspension of a blood-agar-plate twenty-four-hour culture of *Streptococcus viridans* were injected beneath the serosa of the gall-bladder and the animals sacrificed at thirty-three to 134 days. On examination, the gall-bladders appeared to be practically normal. No mucus nor stone was found in the lumen which contained a normal-appearing bile.

Group IV.—Cystic-duct ligation with removal of bile and insertion of a human cholesterol-pigment stone, two-thirds centimetre in diameter, into the gall-bladder, and injection of one and one-half cubic centimetres of *Streptococcus viridans* beneath the serosa. One experiment. The dog was killed after 298 days. The gall-bladder was adherent to the surrounding liver, in which there was a hard, inflammatory mass one to two centimetres thick, extending the entire extent of its bed. It was distended with fluid and its wall thickened and indurated. The cystic duct was dilated for two centimetres down to the point of occlusion. An X-ray of the specimen including the liver showed a dense, granular, circular deposit two centimetres in diameter in the region of the gall-bladder. Eighteen cubic centimetres of a turbid, whitish fluid were aspirated. On section a yellowish-white, hard, sand-like deposit was found in the gall-bladder and the human stone was unchanged. Fig. 21 shows a photograph of the gall-bladder and duct dissected free with the human stone removed, but containing the sandy deposit. A röntgenogram (Fig. 22) shows the sand to cast a heavy, granular shadow. Cultures of the fluid yielded *Streptococcus viridans*. Microscopical examination showed considerable fibrosis and a small amount of leucocytic infiltration of the wall of the gall-bladder. Mucosa was intact. Chemical analysis of the sandy deposit showed calcium carbonate, 70.7 per cent.; calcium phosphate, 1.8 per cent.; the rest was organic matter. Chemical analysis of the supernatant aspirated fluid showed calcium, 12.1 milligrams per 100 cubic centimetres; phosphorus, a trace; CO₂, 112.8 volumes per cent.; and pH, 7.28. This represented a concentration of calcium and carbonate ions which exceeded tenfold the solubility product constant necessary for the precipitation of calcium carbonate. It contained 150 milligrams of cholesterol per 100 cubic centimetres. A test for bile pigment was negative.

This experiment duplicates the picture of calcium-carbonate deposition in the lumen of the gall-bladder in the human cases. The deposit is in the same form as that of Case VI.

PHEMISTER, DAY AND HASTINGS

RABBIT EXPERIMENTS

In two rabbits the cystic duct was ligated and one cubic centimetre of a streptococcus injected beneath the serosa. The animals were killed in twenty-two and 113 days. In the twenty-two-day experiment the gall-bladder was slightly contracted and contained mucous material but cast no calcium shadow in the X-ray. In the 113-day experiment the gall-bladder was small and filled with a thick pus which cast a few small shadows of calcium density in the X-ray.

In five rabbits the cystic duct was ligated and a small cholesterol-pigment human stone inserted in the empty gall-bladder. The animals were sacrificed in 135 to 245 days. The gall-bladders were small and three of them showed faint, irregular shadows of calcium deposits in röntgenograms of the excised specimens. On section the implanted stones were found unaltered in all cases and the cavities contained two to four cubic centimetres of a thick inspissated exudate. Chemical analysis showed the presence of calcium.

In two animals the cystic duct was ligated, the gall-bladder emptied, a small human

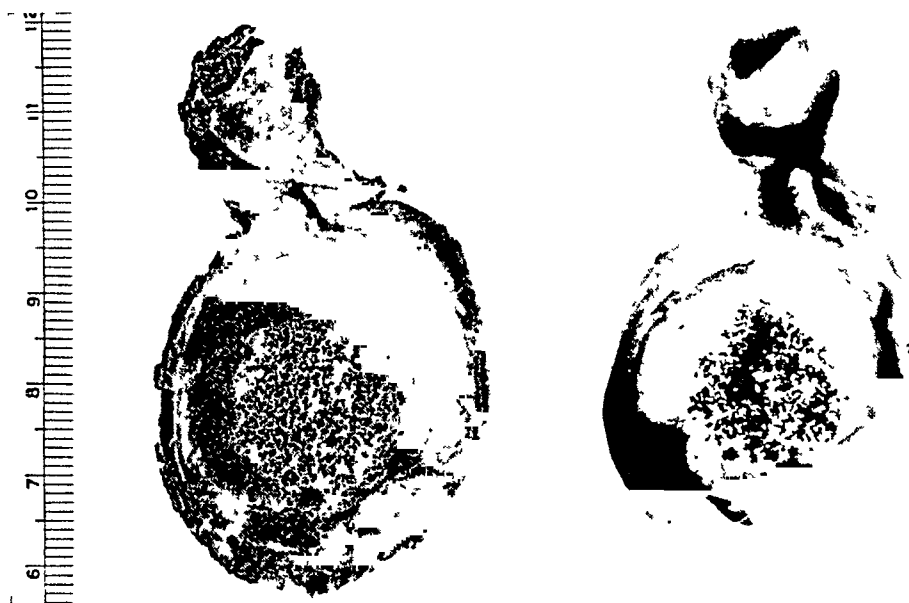


FIG. 21.

FIG. 22

FIG. 21 — (Dog. 22) Opened gall-bladder showing calcium carbonate sand in it 298 days after tying cystic duct.

FIG. 22 — (Dog. 22) Röntgenogram of specimen in Fig. 21, showing granular shadow of calcium carbonate in the gall-bladder.

stone inserted and streptococci injected beneath the serosa. One animal was killed in 137 days. The gall-bladder was moderately thickened and distended with fluid. A röntgenogram of the specimen including the liver revealed a ring-shaped shadow on the surface of the inserted gall-stone, which was present in a röntgenogram taken before its implantation. There were heavy, small, blotchy shadows about the region of the fundus of the gall-bladder.

The three cubic centimetres of clear fluid aspirated from the gall-bladder were insufficient for chemical analysis. There was a slight sediment when the bladder was opened and the wall was moderately thickened. The shadows in the fundus region were of calcium density and a chemical test for calcium was positive but the sediment was too scanty for analysis for carbonate and phosphate content. The other animal was sacrificed in 243 days. The gall-bladder was contracted and filled with a creamy, mucopurulent material. A röntgenogram revealed no shadow cast by either the exudate or the stone in the gall-bladder. The calcium deposits are similar to those produced in the rabbit by Wilkie.

In four rabbits a human stone was inserted into the gall-bladder without duct

GALL-STONES AND THEIR PRODUCTION

ligation or bacterial injection. One animal killed in sixty-two days showed the gall-bladder normal but the stone which weighed .0176 gram before insertion had been reduced to .0112 gram. A second animal killed in 137 days showed no changes in the gall-bladder but the gall-stone had been about one-half absorbed. The third animal killed in 235 days and the fourth in 245 days showed complete disappearance of the gall-stones and no changes in the gall-bladder wall. Similar absorption of human gall-stones from the gall-bladder of dogs has been reported by others, as Walsh and Ivy.³

SHEEP EXPERIMENTS

In one sheep the cystic duct was ligated and a stone inserted into the gall-bladder. After 133 days the gall-bladder was found to contain a thick mucus with little change in the wall and röntgenologically there were no calcium shadows to be seen. The inserted stone was unchanged. In a second sheep the cystic duct was ligated and a human cholesterol-pigment stone weighing 0.206 gm. was inserted and streptococci injected beneath the serosa. After 281 days the gall-bladder was found contracted on the stone and containing no fluid. Its wall was fibrosed and the stone was unchanged.

A review of the animal experiments shows that one solid deposit of calcium carbonate in the gall-bladder similar to human Case VI was produced in the dog by cystic-duct ligation and streptococcus injection, setting up a chronic cholecystitis. The implanted human stone was unchanged and appeared to play no rôle. Faint calcium deposits were present in the mucus within the gall-bladders of five rabbits after cystic-duct ligation with bacterial injection in one, bacterial injection and stone implantation in one, and stone implantation in three. The dog experiments contradict the claim of Naunyn that the calcium is secreted with the mucus in that in most of the ligations of the cystic duct of long standing the gall-bladder was filled with very thick mucus and still there was no deposit of calcium carbonate.

Discussion.—The morphological conditions under which calcium carbonate had precipitated from the fluid in the gall-bladder in the human cases observed and in the experimental animals are: (1) Obstruction of the cystic duct, and (2) low-grade chronic inflammation of the gall-bladder with occasional slight exacerbations as indicated by the attacks of colic. The chemical composition of the gall-bladder contents found under these altered morphological conditions gave evidence that calcium and carbonate ions had accumulated to such an extent that the solubility product constant of calcium carbonate had been exceeded and the precipitation of calcium carbonate had resulted. Inorganic phosphate was present only in such small amounts that the solubility product constant of calcium phosphate had been rarely exceeded, and consequently only traces of solid calcium phosphate were found.

It is not possible as yet to state with exactitude the calcium-ion concentration in the gall-bladder fluids analyzed. There was so little exudate and so much mucus in five of the human cases that an analysis was impossible. However, if in the cases where fluid is obtainable one assumes that all of the calcium present in solution is in ionic form; and if one calculates the carbonate concentration from the pH and CO_2 according to the equations of Hastings, Murray and Sendray, one may determine whether or not the product (Ca) by (CO_3) is of an order of magnitude compatible with the existence of solid calcium carbonate.

This was done for fluids from the gall-bladders of Case VI and Dog

No. 22 (Fig. 21) both of which contained solid calcium-carbonate deposits.

The equilibrium product, 4 by 10^{-8} , was exceeded tenfold in the dog fluid. In Case VI it was not equalled but an acute attack of cholecystitis had just preceded the cholecystectomy, which may have been responsible for fresh exudation that temporarily lowered the ionic concentration. In fluids from a case of hydrops of the gall-bladder secondary to obstruction of the ampulla by a large cholesterol stone which previous to engagement had acquired a ring deposit of calcium carbonate the product (Ca) by (CO_3) was only one-tenth that required for the existence of solid calcium carbonate. It is noteworthy that from röntgen ray and gross examination calcium carbonate appeared to have been dissolved off the end of the stone protruding into the cavity, since the fluid had accumulated.

It is not possible at the present time to offer an adequate explanation for the accumulation of calcium and carbonate, and the total or almost complete absence of inorganic phosphate within the gall-bladder under the conditions just described. As a working hypothesis one may assume the entrance into the gall-bladder of an exudate, practically free of inorganic phosphate with a normal concentration of calcium and bicarbonate. This exudate is unable to leave the gall-bladder, however, due to the obstruction of the cystic duct. Consequently, upon subsequent concentration of the fluid either as a result of subsidence of inflammation or by the special concentrating power of the gall-bladder such as it exercises on bile, conditions are rendered favorable for the precipitation of calcium carbonate. That another lining membrane will hold back inorganic phosphate was shown by C. B. Huggins,⁴ who found it completely lacking in spermatocoele fluids. Another hypothesis would be to assume that the mucosa of the gall-bladder under these altered morphological conditions "secretes" calcium carbonate as the gastric mucosa secretes hydrochloric acid.

CALCIUM CARBONATE DEPOSITS ON GALL-STONES

The demonstration that the calcium carbonate forming separate deposits in cases of cystic-duct obstruction comes from the wall of the gall-bladder has raised the question as to whether the calcium carbonate deposited secondarily on the surface of cholesterol or cholesterol pigment stones also comes from the wall of the gall-bladder and of the possible relationship of the occurrence to temporary gall-bladder stasis produced by either calculous obstruction complete or incomplete or by inflammation.

Cholecystography was carried out on forty-four of the forty-eight cases operated on after intravenous tetriodthalein administration. In twenty-five of these no shadow was present in the gall-bladder region in the preliminary röntgenogram. Six of these showed normal, and seven subnormal visualization after dye administration with radio-translucent stones. One showed faint visualization but no radio-translucent stone and operation revealed numerous small stones. Nineteen cases showed radio-opaque shadows in the gall-bladder region before dye administration. Deducting the six with cystic-duct obstruction and separate calcium carbonate deposits there were

thirteen cases in which the stones alone cast radio-opaque shadows. Cholecystography in these cases showed non-visualization of the gall-bladder by the dye in ten, poor visualization in one and good visualization in two. The calcium was in the form of a secondary or ring deposit in the stone in all cases except one, in which there was good visualization. In that case it was largely a nuclear deposit. In the thirteen cases a stone in the cystic duct was found at operation in only one.

The analysis shows that when ring deposits of calcium carbonate casting radio-opaque shadows were present on stones the concentrating function of the gall-bladder was lost in a very high percentage of cases, whereas it was present in normal or reduced amount in the majority of cases of gall-bladders containing radio-translucent stones. How much this tendency to ring deposits of calcium on stones in gall-bladders with loss or marked impairment of concentrating function was due to obstruction and how much to disease of the gall-bladder wall it was difficult to determine, but both factors undoubtedly played a rôle. A stone may obstruct temporarily after which it either passes back into the gall-bladder or on through the ducts. That the calcium may be laid down on the stones during periods of stasis is indicated by the fact that ring deposits were present on stones in four of the six cases of duct obstruction with separate calcium carbonate deposits. Fig. 23 is a röntgenogram of a gall-bladder, the cystic duct of which was partially obstructed by a stone at the orifice. It contained a dark, stringy bile. Calcium carbonate apparently was being laid down on the cholesterol-pigment stones that were present and also there was a small soft mass that was being deposited separately as seen in the röntgenogram.

Summary.—Among forty-eight consecutive cases operated on for gall-stones the cystic duct or ampulla was obstructed by stone in eleven, or 22.88 per cent. Five of these cases, or 10.4 per cent., presented the picture of ordinary hydrops of the gall-bladder. The remaining six cases, or 12.48 per cent., presented separate deposits in a partially collapsed gall-bladder of calcium carbonate varying in density from a mucous suspension in one case to a semi-solid paste in four cases and a dense coarse sand in one case.

A solid coarse sand-like deposit of practically pure calcium carbonate was produced experimentally in the dog by ligation of the cystic duct, injection of streptococci and implantation of a human stone in the gall-bladder. Small calcium deposits were obtained by similar procedures in rabbits. From the human cases and the animal experiments it appears that obstruction to the outlet of the gall-bladder at least of a high degree and a low-grade chronic inflammation are essential for the formation of separate deposits of calcium carbonate in the gall-bladder. The limited chemical analysis of gall-bladder fluids indicates that the calcium carbonate is precipitated from a solution in which calcium and carbonate ions accumulate in amounts which exceed the solubility product constant. The calcium is derived from the wall of the gall-bladder. The absence of cholesterol in the fluid beyond the amounts contained in exudates speaks against the wall of the gall-bladder being the source of cholesterol in gall-stones.

It was apparent from a study of the series of cases in which cholesterol or cholesterol-pigment gall-stones contained secondary ring deposits of calcium carbonate, with cystic duct either obstructed or unobstructed that the calcium carbonate is laid down in gall-bladders with disturbed or lost concentrating function either as a result of inflammation or of inflammation plus calculous obstruction complete or incomplete. The conditions indicate that the ring deposits of calcium carbonate come from the wall of the gall-bladder.



FIG 23

FIG 23—Röntgenogram of liver and gall bladder of a rabbit 137 days after ligation of cystic duct, insertion of human stone, and injection of streptococci in wall, (y) is calcareous shadow within the fundus of gall bladder, (x) is human stone at its outlet



FIG 24

FIG 24—Röntgenogram of gall bladder with loose obstruction of cystic duct by stone. Calcium carbonate deposition taking place simultaneously on surface of cholesterol pigment stones and as independent flakes in its fluid content

BIBLIOGRAPHY

- Phemister, D. B., Rewbridge, A. G., and Rudisill, H., Jr.: Calcium Carbonate Gall-stone and Calcification of the Gall-bladder Following Cystic-duct Obstruction. *ANNALS OF SURGERY*, October, 1931.
- Romang, F.: Beitrage zur Rontgendiagnostik der Cholelithiasis. *Fortschr. Roentgenstrahlen*, vol. xxxv, p 119, 1927.
- Wilkie, A. L.: The Bacteriology of Cholecystitis; a Clinical and Experimental Study. *Brit. Jour. of Surg.*, vol. xv, p. 450, 1925.
- Walsh, E. L., and Ivy, A. C.: Observations on the Etiology of Gall-stones. *Annals of Intern. Med.*, vol. iv, p 134, 1930.
- Hastings, Murray, and Sendray: Studies of the Solubility of Calcium Salts. *Jour. of Biolog. Chem.*, vol. lxxi, 1927.
- Huggins, C. B.: Biochemical Studies of Seminal-tract Fluid. *Transactions of American Physiological Society*, 1932. To be published.

THE MECHANISM OF CHOLESTEROL GALL-STONE FORMATION

BY EDMUND ANDREWS, M.D., L. E. DOSTAL, M.D., M. GOFF, M.D.

AND L. HRDINA

OF CHICAGO, ILL.

IN A series of recent communications,^{1, 2, 3} it was shown that the cholesterol in the bile was held in solution in a chemical combination with the bile salts. Experiments, *in vitro*, indicated that this complex could be broken up by dialysis, the bile salts passing through the membrane and the cholesterol being left behind and precipitated. Analyses of the bile of normal and diseased gall-bladders both in dogs and human beings indicated that while the normal gall-bladder was impermeable to bile salts, the diseased viscus was quite permeable and acted as a dialysing membrane, permitting the solvent, the bile salts, to pass out and the cholesterol to be precipitated with the consequent implication of gall-stone formation.

Our experiments indicated that on the average thirteen molecules of bile salt were necessary to hold one of cholesterol in solution. Owing to variations in the type of bile salt as well as other unknown factors, this figure is only approximate and varies between ten and fifteen. In other words, if the bile salt-cholesterol ratio is below thirteen the bile is saturated and precipitation is liable to occur. In normal human bile, according to the analyses of Hammarsten,⁴ the bile salt-cholesterol ratio is forty. The more recent studies of Newman⁵ put the figure at seventeen. These analyses were made on post-mortem material and the figures probably err slightly on the lower side, as it is obvious from the work of Whipple⁶ and our own experiments⁷ that during the agonal period the secretion of bile salts would be at a minimum. This fact is borne out from a study of our own operative specimens. They include biles removed from gall-bladders, which were not diseased (cholecystenterostomy, four cases; common-duct exploration, two cases; normal gall-bladders on histological examination post-operative, three cases). In this series of nine cases the bile salt-cholesterol ratio was twenty-five. (Table I.)

In very striking contrast was the analysis of bile removed from diseased gall-bladders. Our series of analyses has now been extended to fifty-three. In this entire series the bile salt-cholesterol ratio was 2.5. This is exactly one-tenth of the ratio in the control series and to our minds offers quite definite proof that the diseased gall-bladder absorbs bile salts at the expense of cholesterol. Further proof is that in all gall-bladders in which cystic-duct obstruction has been present for long periods the bile salts had all been absorbed and the cholesterol was not held in solution, and the oft-observed fact that in biles not containing any bile acid the cholesterol was entirely in crystalline form and not in solution.

It has been stated from the time of Naunyn that cholesterol was excreted by the gall-bladder wall. If this were a fact it would of course offer an obvious explanation of the above findings. Our experiments, however, have

TABLE I.

ANALYSES OF BILE FROM NORMAL AND DISEASED HUMAN GALL BLADDERS

No. of cases		B.S./Chol. Ratio
2	Hammursten (normal)	40
11	Newman (normal)	17
9	Our controls	25
51	Diseased gall bladders	2.5

failed to substantiate this claim. Table II, taken from a recent publication, shows beyond a doubt that the gall-bladders, of dogs at least, do not have this function. While common-duct ligature has been shown to produce some

TABLE II.

CHOLESTEROL CONTENT OF GALL BLADDER BILE IN STASIS

Controls 36 dogs with stasis of 24 hours or less	Average 57 Mg per 100 cc.
42 dogs with common duct ligature 3-58 days	Average 51 Mg per 100 cc.

slight changes in the histological appearance of the gall-bladder as well as the finding of bacteria in the ordinarily sterile dog bile, the changes are not marked and evidently do not interfere with the normal absorptive mecha-

TABLE III.

ANALYSES OF BILE FROM NORMAL AND DISEASED DOG'S GALL BLADDERS

No. of exps.		Bile Salts	Chol.	B.S./Chol. Ratio
81	normal controls	3630	55	66
57	diseased	1028	47	24

Figures for bile salts and cholesterol in milligram per 100 cubic centimetres. Cystic ducts closed.

nism. If the gall-bladder has a cholesterol-secreting function it is inconceivable that it would not become evident in such a long series of experiments as this. Further data on this subject are given in a previous paper.⁸

In our original publications,² experiments were cited showing that the gall-bladder of the dog, if diseased, absorbed bile salts at the expense of cholesterol. Since then these observations have been markedly extended. Table III is a summary of the analyses of 138 dogs' bladder bile and amply confirms our previous reports. The numbers involved are quite sufficient to rule out the possibility of the results being explained as due to the wide normal fluctuations in the chemical contents of dog bile. While the cholesterol content of bile from diseased gall-bladders lies quite within the normal range, the bile-salt content is reduced about 65 per cent.

The term "diseased gall-bladder" has been used in this paper with intentional vagueness, as it has been quite difficult to explain just what factors bring about abnormal absorptive phenomenon. These factors may be grouped under four heads: (1) Infection, (2) stasis, (3) circulatory changes, and (4) chemical damage, from the entrance of pancreatic juice as suggested by Wolfer, or even intestinal juices.

In these studies it has proven very difficult to differentiate the factors of stasis and infection. Does stasis or infection, or both, cause the absorption of the bile salts and hence gall-stone formation? The separation of these two factors is so difficult because each in turn will cause the other. In a previous communication⁹ it was shown that ligation of the cystic duct in dogs caused the prompt invasion of the gall-bladder by the rich liver flora. This has been demonstrated both bacteriologically and histologically in over fifty dogs. Ligation of the common duct with resultant stasis produces also slight inflammatory changes, but to a very much smaller degree. Recent experiments have shown that in dogs at least the gall-bladder infected by injection of an emulsion of streptococci under the serosa fails to visualize after intravenous iodokon injection. Examination of such a gall-bladder reveals the fact that for a week or two after such infection the cystic duct appears to be swollen shut.

With the object of attempting to evaluate the importance of these four factors and to determine the importance of each in gall-stone formation the following experiments were undertaken.

Stasis.—While as above stated the production of stasis by common-duct ligation is not entirely free from criticism on the basis of resultant infection, this infection is in most cases minimal and the gall-bladder remains grossly normal although histological changes are usually found. The following series of experiments therefore may be said to show the effect of stasis alone, or at least with the least possible element of infection superimposed. The new element of jaundice is of course introduced, but this is unavoidable. The secretion of the damaged liver as has been shown by a number of observers, is much more apt to have a low bile-salt content than a low cholesterol content. The reports of Whipple,¹⁰ Walters,¹¹ and Andrews⁷ may be cited on this issue. In view, however, of the negative character of the results found, this fact only adds to the value of the conclusions.

Fifty-one dogs were used. Ten were controls, sacrificed after a short period of starvation. The remaining forty-one were operated upon under ether anaesthesia and the common duct ligated as close to the duodenum as possible. These dogs were kept on an ordinary mixed diet. Some died and some were sacrificed at various periods up to eighty days. The cystic ducts were clamped, the gall-bladders excised and emptied. In each case the amount of bile salts was determined by the amino-nitrogen method and the cholesterol colorimetrically.

The data thus acquired are given in Table IV.

The results of these experiments are so clear-cut as hardly to require any comment. While, as in all dog experiments, the individual figures varied rather widely, the average for the different groups fell quite within the limits of experimental error. The bile salt-cholesterol ratio for each of the groups was approximately the same and there is no tendency for the later

TABLE IV.

EFFECT OF STASIS ON BILE SALT - CHOLESTEROL RATIO

	No. of Exps.	Chol.	B.S.	B.S.-Chol. ratio
Controls	10	67	3650	54
1 day	5	56	3002	54
3-5 days	9	69	3157	45
6-12 days	12	77	4741	61
12-42 days	8	24	1219	52
44-80 days	7	41	2034	49

Figures for bile salts and cholesterol in milligram per 100 cubic centimetres. Stasis produced by ligation of common duct near duodenum.

figures to be smaller. In other words, in long-continued stasis produced by common-duct ligation there is quite definite evidence against any excretion of cholesterol by the gall-bladder wall, as well as evidence against any differential absorption of bile salts at the expense of the cholesterol. The bile salt-cholesterol ratio is not lowered by stasis in the gall-bladder alone and the introduction of some other factor is necessary. Differences in the absolute value of bile salts or cholesterol are explained by varying amounts of water in the gall-bladder. In view of the possibility of flow back and forth into the dilated common duct, no studies of the total gall-bladder contents were made.

Infection.—Since stasis alone is shown not to cause absorption of bile salts, the effect of bacterial injection was tried. The materials injected were first streptococci and secondly a filtered emulsion of dogs' faeces. The

CHOLESTEROL GALL-STONE FORMATION

latter were used in place of pure cultures as it was thought they gave a better general representation of the intestinal flora. The gross effects of the streptococci were much less than of the fecal emulsion. Nine experiments in which they were injected into the subserous coats of the gall-bladder resulted in no chemical changes in the bile at all and are not included in the table. Introduction of either streptococci or fecal emulsion into the gall-bladder by needle puncture or injection up the common duct with a ureteral catheter into the gall-bladder as can be seen from Table V produced the prompt onset of profound chemical changes in the constituents of the bile. The degree of cholecystitis was severe and the bladders were shrunk and contained but small quantities of very inspissated bile. Several specimens

TABLE V.

INJECTION OF BACTERIA INTO DOG'S GALL BLADDER

No. Exps.		B.S.	Chol.	B.S./ Chol.
4	2 cc cloudy suspension of streptococcus injected up common duct into gall bladder with catheter.	1706	92	19
2	2 cc same thru needle puncture into lumen.	1545	111	14
4	2 cc filtered emulsion dog feces up duct.	88	86	1
3	2 cc same into lumen	217	118	2
2	2 cc same subserous	1230	300	4
	Average	893	126	7
81	Normal controls	3630	55	66

Figures for bile salts and cholesterol in milligram per 100 cubic centimetres. Duration of experiments four days.

not included in the table had to be discarded as there was not sufficient bile for analysis. The results shown indicate that the factor of infection is the important one in bringing about bile-acid absorption. In the experiments with the streptococcus the lowering of the bile salt-cholesterol ratio is moderate, the average being twenty-two against a normal of about sixty-six for dogs. In the case of the faeces it corresponds with the obvious gross changes and is much more marked.

It has been stated by some observers that the action of bacteria alone on bile is capable of destroying the bile acids or cholesterol. Most of this work was done before the advent of modern chemical methods of bile-salt analysis. All workers with sterols have long recognized their extraordinary resistance to bacterial action. Even when incubated with faeces or passed through the

gastro-intestinal tract they may be recovered quantitatively. The cholic-acid radical which is extraordinarily similar to cholesterol is similarly resistant. It is true that the combined bile acids may be hydrolyzed by bacteria to form simple ones plus glycocholic or taurine, in which case they would not show on amino-nitrogen determinations. This, however, occurs only in the presence of marked putrefactive changes and in short-time experiments such as reported here is not a factor in the results, as is shown by the following experiments. Five per cent. solutions of bile salts were inoculated with a loopfull of streptococci, staphylococci, *B. coli* and *B. Welchii* and faeces. Analyses of samples of this mixture were made at once, in twenty-four hours, three days and five days. In no case was there found any appreciable lessening of the combined bile acids, although all the solutions had become cloudy with bacteria. A series of thirty-six such analyses was made and in no case was evidence forthcoming of any destruction of bile acids. One must conclude, therefore, that our previous experimental findings represent an absorption, not a destruction, of bile acids.

In these experiments it is seen that there is an increase in the cholesterol content of over 100 per cent. Such changes have been interpreted by Naunyn,¹² and, more recently, by Elman and Graham,¹³ as indicative of excretion of cholesterol by the gall-bladder mucosa. While this factor may play a rôle it seems to us exceedingly unlikely that it is a major one for the following reasons: In experiments with gall-bladders in which cystic ducts are ligated there is no increase in the cholesterol content. Table III presents evidence on this score. Tables II and IV also indicate that obstruction of the common duct does not lead to accumulation of cholesterol in the gall-bladder. In this group (Table V) the cystic duct was open and it was quite possible for bile to continue to pour into the gall-bladder and the cholesterol to remain while the water and bile salts were absorbed. The results may also be explained by the fact that the gall-bladders' contents were considerably smaller at the end of the experiments than at the beginning and the rise in the cholesterol concentration may be simply due to concentration of the bile by absorption of water.

Circulatory changes.—These are almost impossible to evaluate. In the previously reported series of experiments where dogs' cystic ducts were tied, great care was taken to avoid the cystic artery and this was usually checked post-mortem. However, the blood supply to the dogs' gall-bladder is complicated and it is manifestly impossible to tie the duct without damaging the vascular elements. Microscopical examination of this region shows a very rich network of vessels closely associated with the duct, which must certainly be tied even if the main cystic artery is preserved. Therefore in such experiments circulatory changes cannot be ruled out.

A few attempts were made to ligate the artery without injuring the ducts. The results were so inconsistent that no detailed studies on this type of experiment can be reported.

CHOLESTEROL GALL-STONE FORMATION

Chemical irritation.—The possibility of reflux of pancreatic juice into the gall-bladder with resultant cholecystitis has been thoroughly reviewed

TABLE VI.

EFFECT OF PANCREATIC JUICE ON GALL BLADDER CONTENTS

No.	Experiment	Time Days	B.S.	Chol.	B.S./ Chol.
1	8 cc. Berkfeld filtered juice thru needle puncture.	4	2673	40	66
2	5 cc.	4	446	47	9
3	7	4	0	52	0
4	4	4	2232	43	51
5	5	4	2722	90	30
6	5	4	942	100	9
7	7	4	2417	47	51
8	5	4	1546	70	22
9	4	4	2947	83	35
10	6	4	666	70	9
11	5	4	2920	62	47
12	2 cc. filtered juice thru common duct in. g.b. Duct tied.	2	0	25	0
13	"	4	0	125	0
14	"	2	0	25	0
15	4 cc. unfiltered juice thru needle puncture.	4	0	0	0
16	"	4	0	0	0
17	"	4	0	0	0
18	"	4	0	0	0
19	"	4	0	0	0
Average			1027	63	16
Average 81 normal controls			3630	55	66

Figures for bile salts and cholesterol in milligram per 100 cubic centimetres.
recently by Wolfer¹⁴ and needs no further discussion. The accompanying Table VI shows very clearly that in dogs at least this causes prompt changes

in the permeability of the viscus to bile salts, which are rapidly absorbed. There is a profound fall in the bile salt-cholesterol ratio to very low levels. While the cholesterol content of the bile remains about the same about one-third of the bile salts are absorbed and in many of the experiments, especially with the unfiltered juice, all the bile salts were absorbed. *In vitro* experiments show that these changes represent an absorption and not a destruction of bile salts by pancreatic juice. At any rate it is obvious from these results that pancreatic juice may be a factor in gall-stone formation.

This thesis is also supported by the following clinical observations. The bile and gall-bladder wall have been cultured in a series of twenty-three cases, which for various reasons must be classified as acute, either due to clinical activity present or less than three days pre-operative, and confirmed by the findings of leucocytic infiltration of severe degree. Fifteen of these cases showed either a sterile bile or sterile gall-bladder wall. Two of the cases were especially striking as they showed the gall-bladder grossly acutely inflamed and covered with fibrin, being very thick and white in color. The post-operative course of these two patients was also remarkable in being smooth, afebrile and not stormy, as was expected from the operative findings.

Thus, while entrance of pancreatic juice into the gall-bladder cannot be positively stated to be a factor in disease, it appears at least to be a possible one and amply deserves further study.

CONCLUSIONS

- (1) Cholesterol gall-stones may result from the absorption of bile salts by the diseased gall-bladder with consequent precipitation of cholesterol.
- (2) Cholesterol is not excreted by the gall-bladder mucosa.
- (3) Stasis alone does not result in stone formation.
- (4) Injury to the gall-bladder wall by bacterial or other toxic agents appears to be the important factor.

BIBLIOGRAPHY

- ¹ Schoenheimer, R., and Hrdina, L.: The Etiology of Gall-stones. I. Chemical Factors. *Proc. Soc. Exp. Biol. and Med.*, vol. xxviii, p. 944, 1931.
- ² Andrews, E., Schoenheimer, R., and Hrdina, L.: The Etiology of Gall-stones. II. Rôle of the Gall-bladder. *Proc. Soc. Exp. Biol. and Med.*, vol. xxviii, p. 945, 1931.
- ³ Andrews, E., Schoenheimer, R., and Hrdina, L.: The Etiology of Gall-stones. III. Bile Salt-Cholesterol Ration in Human Gall-Stone Cases. *Proc. Soc. Exp. Biol. and Med.*, vol. xxviii, p. 947, 1931.
- ⁴ Hammarsten, O.: *Physiological Chemistry*. New York, 1911.
- ⁵ Newman, C. E.: *Beitrag zum Studium der Gallenneiderschlags und Gallensteinbildung Beiträge zur Pathologischen Anatomie*, vol. lxxxvi, p. 187, 1931.
- ⁶ Whipple, G. H.: The Origin and Significance of the Constituents of the Bile. *Physiological Reviews*, vol. ii, p. 440, 1922.
- ⁷ Andrews, E., Hrdina, L., and Dostal, L. E.: Studies on the Etiology of Gall-stones. II. Analysis of Duct Bile from Diseased Livers. *Arch. of Surgery*. In Press.
- ⁸ Dostal, L. E., Hrdina, L., and Goff, M.: Is Cholesterol Excreted by the Gall-bladder Mucosa? *Proc. Soc. Biol. and Med.*, vol. xxix, p. 541, 1932.

CHOLESTEROL GALL-STONE FORMATION

- ⁹ Andrews, E., and Hrdina, L.: Hepatogenous Cholecystitis. *Arch. Surg.*, vol. xxiii, p. 201, 1931.
- ¹⁰ Whipple, G. H.: Bile-salt Metabolism. *Jour. Biol. Chem.*, vol. lix, p. 623, 1924.
- ¹¹ Walters, W.: Obstructive Jaundice. The Mayo Foundation Publications, 1931.
- ¹² Naunyn, B.: A Treatise on Cholelithiasis. New Sydenham Society, London, 1896.
- ¹³ Elman, R., and Graham, E. A.: The Pathogenesis of "Strawberry Gall-bladder." *Arch. of Surg.*, vol. xxiv, p. 14, 1932.
- ¹⁴ Wolfer, J. A.: The Rôle of the Pancreatic Juice in the Production of Gall-bladder Disease. *Surg., Gynec., and Obst.*, vol. ciii, p. 443, 1931.

DISCUSSION.—DR. EDWIN BEER (New York City) said if he understands the report of Doctor Phemister correctly, the production of the calcium deposits usually takes place in the obstructed gall-bladders, whether cystic obstruction be due to gall-stone or not, provided a mild inflammatory reaction persists in the mucous membrane and gall-bladder wall.

It is interesting to note that visualization of the gall-bladder stones is accomplished by virtue of the fact that a ring deposit of calcium is placed upon their nuclei by similar changes.

In the urinary bladder and the upper urinary tract there are non-opaque stones which are shown by röntgen-ray only after the mucous membrane of the bladder or the ureter has thrown down some calcium which deposits as a ring around the stones, making stones that previously were invisible stones, opaque to the röntgen-ray, a process analogous to that which is seen in the biliary tract.

As far as Doctor Andrews' presentation was concerned, it was very difficult to follow the tables, but the speaker had the impression from his own studies of the urinary and biliary tracts that the fundamental causative factor in the production of stones is colloidal instability associated with stagnation; whether that is due to a diminution of the bile salts or whether it is due to some mucous-membrane change (avitaminosis?), he did not know. He also said if Doctor Andrews' conception as to the influence of the bile salts was correct, one would expect a regular deposition of crystalloids in one of the experimental series.

One of the most striking instances of this instability that he had observed had been in peripheral phosphaturia cases in the urinary tract. Here a patient may pass milky phosphaturic urine, and immediate catheterization of the bladder may show absolutely clear urine. Just what produces this upset in the urinary tract, or what induces the instability, whether changes in the hydrogen ion concentration, electrical reactions or what-not, is unknown. Such peripheral phosphaturias have developed in the short female urethra.

Whether the same thing happens in the biliary tract does not lend itself to study, but in the behavior of the kidney, ureter and bladder we can suspect a similar colloidal instability in the biliary tract underlying the deposition of crystals and stones.

DOCTOR PHEMISTER in reply to Doctor Beer remarked that both infection and obstruction are factors in the deposition of calcium carbonate in the gall-bladder. It does not appear that infection alone will make pure calcium carbonate gall-stones but ring deposits on pre-existing stones are laid down in its presence. Pure calcium carbonate as a separate deposit comes only with duct obstruction. In the reported cases of duct obstruction and calcium-carbonate deposition in the gall-bladder there was no evidence of cholesterol deposition from the gall-bladder wall and the fluid in the cases of experimental obstruction always contained less than 150 milligrams of cholesterol per 100 cubic centimetres, which is no greater than is ordinarily found in exudates.

DR. EDMUND ANDREWS (Chicago) said as to the question of sudden crystallization of supersaturated materials, it is obvious that the least temperature change, or trauma,

or anything else of that sort would explain the phenomenon that Doctor Beer spoke of as a "sudden colloidal change." When urine leaves the bladder and lands in a cold vessel, it will immediately crystallize, but those we mean are those that occur in the gall-bladder and not after it gets out.

As to the experiments of Doctor Wilkie his and one other set of experiments report the formation of cholesterol gall-stones in experimental animals. They are the only records that I know of that make such a report. I have repeated both sets and I have seen both sets repeated by other observers in a very large number of cases, and I have never heard of a cholesterol gall-stone formed in any experimental animal nor any animal except man. That is due to the fact there is not enough cholesterol in the bile of a dog. It is exceedingly low in a dog. In the liver bile it is ten milligrams and in the fistula bile it is less.

We have repeated the experiments reported and we were never able to find any cholesterol content. We never found any increase in the total cholesterol content of the gall-bladder. You get an increase in concentration due only to the absorption of water.

As to the relation of the blood cholesterol and gall-stones, the recent work of McNee and Campbell, and especially a long series of English observers, has completely dissociated any such factor whatsoever. Campbell does not know of any figures today that will demonstrate that there is any more cholesterol in the blood of a person with gall-stones than there is with a normal human being, and he knows a great many long series of figures that strongly controvert that point. He said we now know the vast majority of the cholesterol, according to the work of Sperry, is secreted in the bowel and not into the bile. The best example he knows of is that in the very high blood cholesterols, about the highest we find, in war œdemas and starvation œdemas, which is the one thing that will increase the cholesterol in the bile, he knows of no figures showing increase in the gall-stones in those cases. As to the secretion of the gall-bladder itself, they had done some experiments in which they have opened the gall-bladder of dogs, tied off the cystic duct, and made gall-bladder fistulæ. Such animals become promptly infected and have lots of pus containing a high percentage of cholesterol and a low percentage of calcium being strongly acid. However, in those in a long series, only one such experiment succeeded in that the gall-bladder subsequently closed and stayed clean. In that animal they got a cyst which was full of the same type of milky fluid Doctor Phemister found in the human being with obstruction, and it was all in crystalline form. It contained only twenty-one milligrams of cholesterol, so he thinks it shows that the probabilities are that the calcium is an excretion of the gall-bladder mucosa itself. Whether it is necessary that it should be mildly infected, it is impossible to say, because almost any dog preparation that we make is mildly infected.

TUBERCULOSIS OF THE THYROID GLAND

BY FRED. W. RANKIN, M.D.

AND

A. STEPHENS GRAHAM, M.D.

OF ROCHESTER, MINN.

A SURVEY of the literature of the last decade suggests an increase in the incidence of tuberculous involvement of the thyroid gland, but this probably is relative rather than actual, due, no doubt, to the greater number of goitres that have been operated on during this period, and also to a progressive trend toward microscopical examination of the tissue removed at operation. The disproportion between the actual number of times the thyroid gland is involved in a tuberculous process and the number of times partial thyroidectomy is performed for any cause still remains so considerable as to permit a continuation of the appellation "rare" as hitherto applied to this disease. In the course of microscopical study of 20,758 thyroid glands removed surgically at The Mayo Clinic over a period of eleven years, tuberculosis was diagnosed twenty-one times, an incidence of 0.1 per cent.

Of general interest but of little clinical significance is a consideration of those cases in which the thyroid gland is found at necropsy to be involved in generalized, fatal miliary tuberculosis, with similar involvement of most of the other organs of the body. We are principally concerned here, however, with that form of involvement of the thyroid gland which gives rise to a clinical syndrome referable to thyroid dysfunction, but which, unfortunately, fails to produce symptoms that are peculiar or pathognomonic of tuberculous invasion of this organ.

Albers,¹ in 1847, is accredited by Foerster as being the first to have observed tuberculosis in the thyroid gland. Lebert,⁴⁷ in 1857, reported his observations made at necropsy of involvement of the thyroid gland in a fatal case of miliary tuberculosis. Four years later Rokitanski⁴⁸ made the unqualified statement that tuberculosis never involves the thyroid gland, and Virchow⁵⁰ was of the opinion that by some antagonistic action the association of goitre and tuberculosis is prevented except in extremely rare instances, the result of direct invasion from contiguous tuberculous structures. However, in 1865, he did report two cases of miliary tuberculosis and one of the caseous form observed at necropsy. Opinions of such a positive nature held by these two great pathologists of the middle of the eighteenth century were bound to influence thought along these lines. This probably explains the practice during the middle of the last century of sending patients with tuberculosis to regions in which goitre was endemic in the anticipation that the acquisition of goitre would influence the tuberculosis favorably. Hamburger³⁴ made the statement that a patient with goitre at least never acquires tuberculosis. It is not surprising, under these circumstances, that the condition should be entirely ignored or at least so briefly considered in the text-books of the time, such as those of Heschl,³⁷ Rokitanski,⁴⁸ Cruveilhier,²³ Wagner,⁵² and Virchow.⁵⁰

From the first reported case up to 1893, approximately 120 necropsies were recorded, 107 of which were incident to generalized miliary tuberculosis, whereas the remainder

were associated with chronic pulmonary or glandular tubercular processes. Of the total number, caseation was revealed in three. Cohnheim,¹⁷ Cornil and Ranvier,²⁰ Demme,²¹ Weigert,²² Wölfler,²⁴ Berry,⁹ Voelcker,²⁵ and Perry²⁷ reported one or more cases each, and Chiari,¹⁵ Fraenkel,²⁹ and Hegar³⁰ furnished statistics which tended to show the incidence of involvement of the thyroid gland in fatal cases of generalized or chronic pulmonary tuberculosis. Cohnheim,¹⁷ in studying choroidal tuberculosis in cases of miliary tuberculosis, rarely failed to note tubercles in the thyroid gland. The report of Cornil and Ranvier,²⁰ in 1870, which was the first account of a minute histological investigation, served as an impetus to more careful consideration of the histogenesis of tuberculosis of the thyroid gland. Quinlan,²³ in 1871, first suggested that the specific changes in the thyroid gland which could regularly be found in acute miliary tuberculosis could also be found in the chronic forms of pulmonary tuberculosis. This, together with his personal observation of the simultaneous occurrence of advanced pulmonary involvement and tubercles in a follicular struma, led Demme,²⁴ in 1878, to question the accepted antithesis between the thyroid gland and tuberculosis. Chiari¹⁵ found invasion of the thyroid gland in seven of 100 carefully studied cases of acute and chronic tuberculosis; Fraenkel²⁹ found such invasion five times in a series of fifty necropsies in which chronic tuberculosis was demonstrated; Hegar,³⁰ in 1891, on the other hand, reported only fifty-seven instances of involvement of the thyroid gland at necropsy of 1,563 tuberculous subjects. Fraenkel's publication, in 1886, revealed a particularly thorough investigation of this subject. Nather²⁸ stated that after Koch's discovery of the bacillus of tuberculosis he was the first to look for the organism in its specific tissue, and after such studies he stated that the tubercles in the thyroid gland contained few bacilli, a fact he explained on the basis that either the bacillary invasion from the beginning was sparse, or that a large number of bacilli was rapidly destroyed; this latter conception appealed to him as the more likely. He also found the thyroid gland to be regularly involved in acute miliary tuberculosis but that relatively few cases were involved in chronic tuberculosis. Surgery in such cases, he stated, would be of no avail.

At the turn of the century, and particularly during the first decade of the present century, the knowledge of tuberculosis of the thyroid gland became more general. It is true that a few of the text-books such as those of Rindfleisch,³¹ Langerhans,⁴⁶ and Schmaus⁷¹ did not mention tuberculosis of the thyroid gland, but Ewald,²⁵ Eiselsberg,²⁷ Ziegler,²⁸ Ribbert,⁶⁵ Kaufmann,⁴³ and Aschoff⁴ at least mentioned such an occurrence, and Bérard⁵ considered the subject extensively. Although, during the previous fifty to sixty years, one was led to believe in direct antithesis between the thyroid gland and tuberculosis, at the beginning of the present century the relationship between the two was placed in a new light through the works of the French school. Morin,⁶⁴ in 1895, described sclerosis of the thyroid gland which he frequently observed following death from pulmonary tuberculosis; he reported 348 such cases. Morin observed that patients even with slight enlargement of the thyroid gland showed a greater tendency to improvement and eventual healing. This was in agreement with the frequent coexistence of myxœdema and tuberculosis, which Mackenzie⁵¹ had previously pointed out. Lorand⁵⁰ observed also that tuberculosis occurred with marked frequency when the thyroid gland had been altered by disease or reached a state of exhaustion, or after pregnancy. Roger and Garnier,⁶⁷ in a comprehensive consideration of the sclerotic type of gland described by Morin,⁶⁴ reported having encountered it at necropsy of eleven of twelve tuberculous subjects. Their investigations were confirmed through the almost simultaneous studies of Charrin and Nattan-Larrier.¹⁴ Besides sclerosis they observed proliferation of epithelium in the follicles, and concluded that they were dealing with a state of functional hyperactivity. Moreover, they demonstrated increased colloid content in the acute forms of tuberculosis as well as in other infectious diseases, whereas in cases that ran a chronic course, the colloid appeared to be decreased. They ascribed these changes to circulating tuberculous toxins in the blood and not to the bacillus of tuberculosis. A

TUBERCULOSIS OF THE THYROID GLAND

distinction between this type of sclerosis and fibrosis secondary to bacillary invasion of the thyroid gland will be considered later. Torri,⁷⁷ Kashiwamura,⁴² de Quervain,⁶² and Costa²¹ likewise have written on this subject. Kashiwamura,⁴² in 1901, studied the thyroid gland at necropsy in a large number of cases of patients who had died of infectious diseases. Although he noted sclerosis almost invariably in cases of chronic tuberculosis, he was not inclined to ascribe such change to any specific influence of the bacillus of tuberculosis or its toxins, since he also demonstrated identical sclerosis of the interstitial tissue in typhus, diphtheria, and in a case of gas poisoning. The publications of Poncet and Keriche,⁶⁰ in 1906, and their school of thought popularized the conception of a close relation between tuberculosis and goitre. Nather⁵⁵ found that many cases of ordinary goitre as well as of other benign tumors were in a certain measure supposed to represent a kind of reaction product of a tuberculous infection in the body without, however, the formation of specific granulation tissue.

Costa²¹ and Dumas²⁵ associated exophthalmic goitre with a sort of inflammatory tuberculosis in the thyroid gland, in which the specific lesion was absent. Hufnagel⁴⁰ supported this view, but with certain reservations, and the observations of Dunger,²⁹ and Apelt² that cases of exophthalmic goitre had developed at the termination of an acute infectious disease added further weight to such a contention. Moreover, the similarity in the histological changes in the thyroid glands of animals in which de Quervain⁶² had demonstrated experimental thyroiditis, with the changes in exophthalmic goitre, appeared to indicate a certain relationship between infection and exophthalmic goitre.

Forty-six years after tuberculous invasion of the thyroid gland was first recognized pathologically, Bruns,¹¹ in 1893, reported what appears to be the first recorded instance in which the diagnosis was established at operation. The patient was a woman, aged forty-one years, who sought relief from pain from a goitre of long standing. Recurrent paralysis of the nerves was noted before operation. The gland removed at operation was studied by Baumgarten,⁷ who saw proliferating follicular epithelium take part in the formation of tubercles by transformation into giant cells. Since this report approximately 104 additional clinical cases have been recorded. (Table I.)

Barth's⁹ case, reported in 1884, as well as cases of several other observers, has not been included in Table I; although the patients showed clinical signs of dysfunction of the thyroid gland prior to death, they were not operated on. Moreover, there is some question in Barth's case of the changes in the thyroid gland being syphilitic.

In more than 95 per cent. of the cases it was possible to tabulate the age, sex, presence or absence of tuberculosis elsewhere in the body, type of operation employed and the pathological description of the thyroid tissue removed. There were eighty-three women and seventeen men; in four instances the sex was not given. The average age of the women was thirty-six and a half years, and of the men, twenty-six and eight-tenths years. The age incidence according to decades, in the cases reported in the literature and in the cases studied by us, is tabulated in Table II.

In ninety-seven of the 104 cases in which the information was obtainable there were six cases of tuberculosis elsewhere in the body, either at the time of examination or shortly before. Pulmonary involvement was noted in three cases, and tuberculosis of the knee and of the bone, and scrofula, each was recorded once. There were two cases of suspected pulmonary tuberculosis and a history of repeated attacks of pleurisy in three cases. Partial thyroidectomy was performed in ninety-four cases, incisions and drainage were done in eight and tracheotomy in one case. One patient was cured by the

TABLE I
Summary of Cases Reported in the Literature of Clinical Tuberculosis of the Thyroid Gland in Which Operation Was Performed

Author, Year	Cases	Age, Years and Sex	Evidence of Tuberculosis Elsewhere	Description of Process in Thyroid Gland	Treatment	Comment
Bruns ¹¹ (1893)	1	41 F.	Glands of neck	Tubercles with giant cells in colloid gland	Thyroidectomy	Recurrent paralysis of nerves prior to operation
Schwarz ⁷² (1894)	1	30 M.	None	Cold abscess with tuberculous granulations	Incision and drainage	Recurrent paralysis of nerves prior to operation; organism recovered
Clairmont ¹⁶ (1902)	1	2	None	Tuberculous granulations	Incision and drainage	Compression of trachea required emergency operation
Pupovac ⁶¹ (1903)	1	42 F.	Lungs	Cold abscess	Puncture and drainage	
Corner ¹⁹ (1904)	1	9 F.	None	Cold abscess; miliary tubercles	Incision and drainage	Thyroid insufficiency after operation; death from miliary tuberculosis
Lediard ¹⁸ (1905)	1	21 M.	None	Tuberculous granulations with giant cells	Thyroidectomy	
v. Schiller ⁷⁰ (1908)	1	17 M.	Lungs	Cold abscess; bacilli of tuberculosis found	Incision and drainage	Produced tracheal compression
Ruppanner ⁶³ (1908)	3	30 F. 28 F.	None Scrofula as child	Tuberculosis Caseous tuberculosis in adenoma	Thyroidectomy Thyroidectomy	Tracheal compression caused intervention
Lenormant ¹⁹ (1908)	1	50 F.	None	Adenoma with Basedow's stroma and caseating tuberculosis	Thyroidectomy	Signs of hyperthyroidism at forty-two
Halstead ³³ (1910)	1	40 M.	Trochanter	Caseous tuberculosis with abscess	Curettage and drainage	
Halstead ³³ (1910)	1	28 F.	None	Caseous tuberculosis with abscess	Curettage	Tissue for examination obtained after spontaneous rupture
Creite ²² (1912)	2	43 F. 58 F.	None None	Tuberculosis; numerous tubercles Tuberculous granulations without caseation	Thyroidectomy Thyroidectomy	Caused dyspnoea and dysphagia

TUBERCULOSIS OF THE THYROID GLAND

Pollag ⁶⁹ (1913)	3	58 F. 59 F.	Knee	Adenoma with cascating tuberculosis Tuberculous cascation with abscess	Thyroidectomy Thyroidectomy	Dysphagia prominent Followed amputation of knee for tuberculosis
Camera ¹³ (1912)	1	74 F. 51 F.	None None	Cold abscess Adenoma with tuberculous cascation	Drainage Attempted excision	Pressure symptoms prominent Operative death
Tixier and Savy ⁷⁶ (1913)	1	46 F.	None	Tuberculous granulations	Partial excision	Three weeks after operation dyspnoea developed; death; no necropsy
Arnd ³ (1912)	3	53 F. 32 M. 35 F.	None None None	Adenomatous goitre with cascation Colloid goitre with tuberculosis Colloid goitre with tubercles	Thyroidectomy Thyroidectomy Thyroidectomy	
Uemura ⁷⁸ (1917)	24	20 F. 4 M.*	None	Adenomatous goitre with tubercu- losis	Thyroidectomy	
	3	57 F.	None	Basedow's struma with miliary tu- bercles	Thyroidectomy	Lesion found from examination of 1,400 thyroid glands after thy- roidectomy
		20 F.	None	Basedow's struma with miliary tu- bercles	Thyroidectomy	
		33 F.	None	Basedow's struma with moderate cascation	Thyroidectomy	
	3	39 F. 46 M. 43 F. 23 M.	None None None None	Tuberculous granulations Tuberculosis Moderate cascation Hyperplasia and tuberculosis; con- glomerate tubercles	Tracheotomy Thyroidectomy Thyroidectomy Thyroidectomy	
Mosiman ⁸⁵ (1917)	9	29 F.	History of pleurisy	Colloid and adenomatous goitre with tubercles	Thyroidectomy	
		18 F.	None	Hyperplasia and many tubercles	Thyroidectomy	Signs of hyperthyroidism in seven cases
		60 F.	None	Sarcoma and tubercles	Thyroidectomy	
		25 F.	None	Hyperplasia and tubercles	Thyroidectomy	
		24 F.	History of pleurisy	Hyperplasia and miliary tubercles	Thyroidectomy	

TABLE I (*Continued*)

Author, Year	Cases	Age, Years and Sex	Evidence of Tuberculosis Elsewhere	Description of Process in Thyroid Gland	Treatment	Comment
Plummer and Broders ⁵⁸ (1920)	7	38 F.	History of pleurisy	Adenomatous goitre and considerable tuberculosis	Thyroidectomy	
		47 F.	None	Colloid goitre with tubercles	Thyroidectomy	
		32 F.	None	Hyperplasia, adenomas, and tuberculosis	Thyroidectomy	
		33 F.	None	Scattered cases of tuberculosis and marked parenchymatous hypertrophy	Thyroidectomy	High degree of hyperthyroidism, basal metabolic rate +48, +87 respectively
		30 F.	None	Scattered cases of tuberculosis and marked parenchymatous hypertrophy	Thyroidectomy	
		44 F.	None	Extensive tuberculosis; slight parenchymatous hypertrophy	Thyroidectomy	Moderate hyperthyroidism, basal metabolic rate +26
		53 F.	None	Extensive tuberculosis; slight parenchymatous hypertrophy	Thyroidectomy	Hyperthyroidism mild or absent
		46 F.	None	Extensive tuberculosis; slight parenchymatous hypertrophy	Thyroidectomy	
		37 M.	None	Tuberculous destruction and moderate parenchymatous hypertrophy	Thyroidectomy	
		55 F.	None	Extensive tuberculous destruction of gland	Thyroidectomy	
Rendleman and Marker ⁶⁴ (1921)	1	22 F.	None	Diffuse non-caseating tuberculosis	Thyroidectomy	Myxoedema post-operatively; required thyroid extract daily
	5	14 F.	None	Tubercles in parenchymatous gland containing colloid	Thyroidectomy	Arbitrarily classified tuberculosis of thyroid as due to:
			None	Caseation in colloid gland	Thyroidectomy	(1) tuberculous bacillæmia (2) typho-bacillosis (3) acute miliary tuberculosis
		16 M.	None	Colloid goitre with miliary tubercles	Thyroidectomy	
		26 F.	None	Colloid goitre with miliary tubercles	Thyroidectomy	

TUBERCULOSIS OF THE THYROID GLAND

	17 M.	None	Miliary and caseous confluent tubercles in parenchymatous gland	Thyroidectomy	Correct diagnosis suspected before operation				
Borri ¹⁰ (1924)	1	Lungs (?)	Tuberculosis	Thyroidectomy					
Aubriot ⁵ (1925)	1	Lungs (?)	Tuberculous granulations with caseation	Thyroidectomy					
Jean ⁴¹ (1926)	1	None	Cold abscess	Incision and drainage	Spontaneous healing of sinus				
Coller and Huggins ¹⁸ (1926)	5	None	Adenomatous goitre with considerable caseation	Thyroidectomy					
	42 F.	None	Colloid goitre with miliary tubercles	Thyroidectomy					
	38 F.	None	Miliary tubercles in exophthalmic goitre	Thyroidectomy	Compound solution of iodine had been given				
	29 F.	None	Adenomatous goitre with miliary tubercles	Thyroidectomy					
	52 F.	None	Miliary tubercles in exophthalmic goitre	Thyroidectomy	Compound solution of iodine had been given				
Higgins ³⁸ (1926)	5	None	Moderate hyperplasia with miliary tubercles	Thyroidectomy					
	30 F.	None	Tuberculosis	Thyroidectomy	Hyperthyroidism diagnosed in four cases				
	36 F.	None	Areas of hyperplasia with diffuse interstitial tuberculosis	Thyroidectomy					
	46 F.	None	Hyperplasia and tuberculosis	Thyroidectomy					
	41 F.	None	Tuberculosis	Thyroidectomy					
Smith and Leech ⁷⁴ (1928)	3	None	Diffuse parenchymatous hypertrophy miliary tubercles	Thyroidectomy					
	46 F.	None	Chronic tuberculous thyroiditis	Thyroidectomy					
	36 F.	None	Tuberculous thyroiditis	Thyroidectomy					
Marcuse ⁵² (1928)	2	None	Caseation with marked destruction	Thyroidectomy					
	55 F.	None	Colloid goitre with miliary tubercles	Thyroidectomy					
Frassi ³⁰ (1929)	3	None	Tuberculosis	Thyroidectomy					

* Average age of twenty women, 32.4 years.

Average age of four men, 27.5 years.

TABLE I (*Continued*)

Author, Year	Cases	Age, Years and Sex	Evidence of Tuberculosis Elsewhere	Description of Process in Thyroid Gland	Treatment	Comment
Kipp ⁴⁴ (1929)	1	9 65 F. 45 F.	None None None	Tuberculous caseation Tuberculosis Adenomatous goitre with many giant cells	Thyroidectomy Thyroidectomy Thyroidectomy	Marked hyperthyroidism; basal metabolic rate +91
Villata ⁷⁹ (1929)	1	62 F.	None	Tuberculosis	Thyroidectomy	
Frederiksen and Portman ³¹ (1929)	1		None	Adenomatous goitre with miliary tubercles	Thyroidectomy	
Budd and Williams ¹² (1929)	2	42 F.	None	Sclerosing tuberculosis	Thyroidectomy	
Krafft ⁴⁵ (1929)	1	43 F. 60 F.	None None	Sclerosing tuberculosis Tuberculous thyroiditis with giant cells	Thyroidectomy Thyroidectomy	Also had diabetes Paralysis of recurrent nerve prior to operation
Hofhauser ³⁸ (1930)	1	32 F.		Basedow's struma with miliary tubercles	Thyroidectomy	Moderate hyperthyroidism; basal metabolic rate +26
Meyer ⁵³ (1931)	1	37 F.	Lung	Tuberculous thyroiditis in nodular colloid gland	Thyroidectomy	Sanatorium after operation, prognosis good

TUBERCULOSIS OF THE THYROID GLAND

spontaneous rupture of a cold abscess externally. There were three cases of unilateral recurrent paralysis of nerves prior to operation. Carcinoma of the thyroid gland was diagnosed in each case because of the prevalence of this sign in cases of malignancy. A diagnosis of tuberculosis of the gland prior to operation, or even before a microscopical examination of the thyroid tissue was made, was recorded only twice. From a microscopical study of the tissues removed in the 104 cases the following conditions were reported: Tuberculosis of the thyroid gland, forty-four cases; miliary tubercles, thirty-four cases; tuberculous caseation, seventeen cases, and sclerosing tuberculosis, two cases. Tuberculous abscess was recorded six times. In seventy-two of the 104 cases the tuberculous process was stated to have been found in a colloid, adenomatous, or hypertrophic parenchymatous goitre, occurring five, forty-four and twenty-three times, respectively. On one occasion tuberculosis was associated with sarcoma.

TABLE II

*Age Incidence of Tuberculosis of the Thyroid Gland in Decades**

Sex	0 to 9	10 to 19	20 to 29	30 to 39	40 to 49	50 to 59	60 to 69	70 to 79
Women...	1	4	18	31	25	15	5	2
Men.....	1	2	4	3	3			

* Represents 103 reported cases in the literature together with our twenty-one cases.

CASES FROM THE MAYO CLINIC

Since the report by Plummer and Broders,⁵⁸ in 1920, of all clinical cases of tuberculosis of the thyroid gland in which operation was performed at The Mayo Clinic up to that time, twenty-one additional cases have come to operation. A careful statistical study of the symptoms and signs which in most instances had been recorded in minute detail on special goitre history forms was made of each case. Moreover, microscopical sections of specimens of tissue removed at operation were rechecked in order to confirm the original diagnosis. A few of the more significant figures taken from the tabulated data are presented in Table III. In this manner, we hoped to establish a syndrome of symptoms at least characteristic of the condition, if not pathognomonic. A correlation of these data, however, failed to furnish a criterion by which such a clinical diagnosis could be made. Tuberculous thyroiditis was diagnosed only once, and in this instance the clinical picture was indistinguishable from thyroiditis from other causes except that leucopenia was associated with a slight elevation of the temperature. Although this form of tuberculous involvement may occasionally be diagnosed correctly prior to operation, it is well to note that in only four of our cases did the inflammatory process suggest thyroiditis and in only one case was tuberculosis suggested. Of the remaining seventeen cases, twelve were diagnosed exophthalmic goitre (the pathologist reported a hypertrophic parenchymatous goitre as well as tuberculosis in eight of these), four were considered adenomatous goitres, with or without hyperthyroidism, and one

TABLE III
*Clinical Cases of Tuberculosis of the Thyroid Gland for Which Thyroidectomy Was Performed at The Mayo Clinic**

Case	Age, Years and Sex	Chief Complaints	Clinical Evidence of Hyperthyroidism, Grade	Maximal Temperature Prior to Operation	Basal Metabolic Rate	Diagnosis	Pathological Description of Thyroid Tissue	Comment
1	53 F.	Goitre, nervousness	3	Normal	+66	Toxic adenoma	Diffuse tuberculosis in adenoma of thyroid gland	
2	44 M.	Pain, soreness in neck, fever	2	99.6	+31	Tuberculous thyroiditis	Diffuse tuberculous thyroiditis with marked fibrosis	Myxœdema five weeks after operation; thyroid extract daily; well for eight years after operation
3	41 F.	General malaise	0	99.4	+8	Thyroiditis	Diffuse tuberculous thyroiditis with moderate fibrosis	Well five years after operation
4	30 F.	Increasing nervousness	2	Normal	+25	Exophthalmic goitre	Diffuse miliary tuberculosis in hypertrophic parenchymatous thyroid gland	Well six years after operation
5	19 F.	Extreme irritability, diarrhoea	4	99.6	+76	Exophthalmic goitre	Diffuse miliary tuberculosis in hypertrophic parenchymatous and colloid goitre	Well five years after operation
6	49 F.	Nervousness, weakness	2	Normal	+20	Exophthalmic goitre	Diffuse marked tuberculous thyroiditis in hypertrophic parenchymatous goitre	Well three years after operation
7	49 F.	Weakness, loss of weight, nervousness	2	Normal	+51	Toxic adenoma	Diffuse tuberculous thyroiditis in marked adenomatous goitre	Well five years after operation
8	49 F.	Extreme nervousness	3	Normal	+30†	Exophthalmic goitre; cancer of breast	Diffuse tuberculosis in a hypertrophic parenchymatous and colloid goitre	Well four years after operation
9	53 F.	Loss of weight and strength	2	Normal	+10†	Exophthalmic goitre	Diffuse tuberculosis in adenoma and hypertrophic parenchymatous goitre	Well sixteen months after operation

TUBERCULOSIS OF THE THYROID GLAND

10	37 F.	Heart trouble, goitre	1	99.8	+29†	Exophthalmic goitre; endo- carditis	Colloid goitre with a few mili- ary tubercles; giant cells	Died three years after opera- tion from heart failure
11	43 F.	Loss of weight, weak, nerv- ous	2	99.4	+49†	Exophthalmic goitre	Diffuse tuberculosis with fi- brosis marked; areas of case- ation	Well thirteen months after operation
12	36 F.	Palpitation, nervousness	2	99.8	+30	Exophthalmic goitre	Tuberculosis in a hypertrophic parenchymatous and colloid goitre	Well fifteen months after operation
13	39 F.	Pain and ten- derness in neck	0	100.0	— 2	Thyroiditis	Diffuse tuberculous thyroid- itis with moderate fibrosis	Well seventeen months after operation
14	25 F.	Goitre	0	99.4	— 7	Non-toxic adenoma	Diffuse tuberculosis in an ade- nomatous goitre	
15	68 F.	Palpitation, nervousness	2	99.6	+42†	Exophthalmic goitre	Colloid and fetal adenoma with miliary tubercles	Considerably improved after eight months
16	59 M.	Nervousness, loss of weight and strength	2	99.6	+33†	Exophthalmic goitre	Diffuse tuberculosis in hyper- trophic parenchymatous and colloid goitre	Well at present time
17	70 F.	Palpitation, nervousness, weakness	2	Normal	+19	Toxic adenoma	Diffuse tuberculosis in ade- nomatous goitre	Well at present time thir- teen months after opera- tion
18	54 F.	Goitre, dy- sphagia	0	100.4	+ 8	Thyroiditis	Diffuse tuberculosis in ade- nomatous goitre	Well at present time eigh- teen months after opera- tion
19	37 F.	Marked nerv- ousness and loss of weight	3	Normal	+42†	Exophthalmic goitre	Tuberculosis in a colloid and fetal adenomatous goitre	Died after leaving hospital, of pulmonary embolus
20	42 F.	Rapid growth of tumor of neck	0	Normal	None	Hæmorrhagic cyst of thy- roid gland	Diffuse tuberculous thyroid- itis limited to isthmus	Well at present time eleven months after operation
21	48 F.	Palpitation, weakness, loss of 50 pounds	2	Normal	+22	Exophthalmic goitre in adenomatous goitre	Diffuse tuberculosis in ade- nomatous and hypertrophic parenchymatous goitre with colloid	Gall-bladder removed eight months later; well at present time

* In no instance was there a suggestive history of tuberculosis elsewhere in the body nor was such evidence noted on examination prior to operation or at subse-
quent examination.

† Patient had been taking iodine prior to test.

case was diagnosed hæmorrhagic cyst of the isthmus, because of its sudden onset and rapid increase in size. The clinical syndrome of hyperthyroidism, manifested by increased nervousness and irritability, progressive loss of weight and strength notwithstanding increased appetite and consumption of food, and intolerance to heat, was the outstanding feature in all but five cases. The examining clinician, on the basis of his observation and the laboratory data, classified the cases as follows: a high degree of hyperthyroidism, five cases (Cases I, V, VIII, XV, and XIX, Table III); moderate degree of hyperthyroidism, ten cases (Cases II, IV, VI, VII, IX, XI, XII, XVI, XVII, and XXI, Table III), and little if any hyperthyroidism, six cases (Cases III, X, XIII, XIV, XVIII, and XX, Table III). The basal metabolic rate was + 19 per cent., or more in fifteen cases, + 10 per cent., or less in five, and not obtained in one case. Five patients, four of whom were in the larger group, had been taking compound solution of iodine prior to the metabolism test.

Each patient in this series was subjected to a careful examination before and following operation to determine if there was evidence elsewhere in the body of tuberculosis, particularly in the lungs. In no case, however, was there either röntgenological or clinical evidence of such involvement. During the pre-operative period an elevation in temperature (acute infection of the respiratory tract was ruled out in each instance) between 99.4° and 100.4° F. was noted in eleven cases on more than one occasion.

There were two men and nineteen women in our series. The average age of the men was fifty-one years, and of the women 44.3 years. The ages according to decades in our cases and in those from the literature are shown in Table II. Fifty-four per cent. of the patients were between the ages of thirty and forty-nine years, being almost equally distributed in the fourth and fifth decades.

The pathologists based their diagnosis in our cases on the findings of the characteristic tubercles within which were found one or more giant cells. The tuberculous process was diffuse in seventeen cases, many tubercles being found in most instances as well as an abundance of giant cells. In only one instance was a prolonged search necessary in order to isolate the characteristic evidences of tuberculosis. Considerable fibrosis was noted in six cases, five of which represented pure thyroiditis unassociated with adenomatous or hypertrophic changes; one case was associated with multiple adenomas.

Noticeable difference from other cases of goitre was not observed during convalescence from thyroidectomy with the exception that in about five of the tuberculous cases there was profuse drainage from the wound of a clear watery material which persisted over a period of one to two months. Two-thirds to three-fourths of the thyroid tissue was removed in 70 per cent. of the cases; in four cases the surgeon stated that because of the marked thyroiditis only about half of the tissue was removed since it was feared that the removal of a greater quantity would result in myxœdema. Thyroid insufficiency as manifested by myxœdema developed in only one case, and

TUBERCULOSIS OF THE THYROID GLAND

this patient was one of the group of four in which special precaution was taken to prevent just such occurrence. It would appear that, since thyroid insufficiency has been noted in only three of 125 reported surgical cases (thyroidectomy in 115), under ordinary circumstances the same amount of gland may be removed in tuberculosis as in uncomplicated exophthalmic and adenomatous goitre. The thyroid insufficiency in our case and in the two cases reported in the literature was readily corrected by the administration of thyroid extract. In our case myxœdema developed five weeks after operation and for eight years the patient has taken thyroid extract daily. His general condition is excellent. There was but one death; the patient died from a pulmonary embolus on the twelfth post-operative day, after having been dismissed from the hospital in apparently good condition.

Two patients have not been heard from since operation. Five were living and well five or more years after operation, and the remainder have been communicated with or reëxamined recently. None has shown evidence of continuation of the tuberculous process or the hyperthyroid state. Judging from our observations, and from similar data reported in the literature, the prognosis in such cases is highly satisfactory.

Etiology.—The manner of origin of tuberculosis of the thyroid gland remains obscure. Although it was impossible to locate a focus of tuberculosis outside the gland in any of our cases, and in only a few of those reported in the literature, nevertheless it is probable that all such cases are secondary to some process elsewhere in the body too small to have any clinical significance. It appears remarkable, however, that in approximately 114 clinical cases the thyroid gland should apparently alone become invaded from a primary focus. This is all the more unique when we consider the relative immunity of this structure to tuberculous involvement with the fact that any invasion other than by continuity, must be by the blood-stream since retrograde flow of lymph into the thyroid gland is not possible, due to the potent valves interspersed along these channels. In other words, in such cases the thyroid gland must become invaded as the result of tuberculous bacillæmia. These patients must, it would appear, enjoy a high degree of general immunity to the bacillus of tuberculosis, else fatal generalized miliary tuberculosis would develop. This may explain why, in most of the cases observed after partial thyroidectomy, the patient completely recovers and at least for a number of years shows no evidence either of thyroid dysfunction or of tuberculosis.

The specific microscopical changes peculiar to tuberculosis have been produced experimentally in the thyroid glands of animals by Roger and Garnier,⁶⁷ Torri,⁷⁷ Tomellini,⁷⁸ Shimodiara⁷⁹ and others. Roger and Garnier, using guinea-pigs and rabbits, injected emulsions of the bacillus of tuberculosis into the carotid artery. Torri, employing dogs, made similar injections into the thyroid artery. He concluded that the colloid material in the glands possesses a bactericidal action for the bacillus of tuberculosis since he could not recover bacilli from the colloid of the glands ten days after injection. He further demonstrated that the bacilli became attenuated, after prolonged contact with colloid from goitres of human beings. Tomellini, in a similar manner, experimented

with rabbits. Experiments conducted by Shimodiara are of particular interest in that they probably represent, as Arnd³ has stated, more nearly the true relation of the thyroid gland to tuberculous infection. He employed a constant emulsion of the bacillus of tuberculosis which he injected intravenously into rabbits in decreasing concentrations in such a manner that dilutions which produced tuberculous infection of the thyroid gland, spleen, kidney, and testis, would on further dilution continue to produce the specific lesions in the spleen, kidney, and testis but not in the thyroid gland. Arnd believed that these observations, correlated with the comparative scarcity of tuberculosis of the thyroid gland of human beings, denote a relative immunity of the gland to the bacillus of tuberculosis. Moreover, since in acute miliary tuberculosis the infection is so overwhelming, he is of the opinion that the thyroid gland along with other organs is of necessity involved because of the massive invasion. Such infections, therefore, are not significant in determining the relative susceptibility of the gland to tuberculous infection. More recently, Nather, Gloyne,³² and others have shown that the substance of the thyroid gland of human beings, as well as of various animals, has no bactericidal effect on the bacillus of tuberculosis *in vitro*. Nor does thyroid gland administered to experimentally infected animals over a course of several weeks arrest the disease.

Gloyne found little evidence for supposing that the thyroid gland itself has any direct antitoxic action in tuberculosis. He suggests that it is possible there is some anatomical reason that the gland so frequently escapes infection, and cites the heart and voluntary muscle as similar examples of this relative immunity.

Plummer and Broders are of the opinion that the relationship between hyperthyroidism and tuberculosis of the thyroid gland is not a coincidence. They stated: "Either a hypertrophic gland is rendered more susceptible to invasion by the bacillus of tuberculosis or the infection stimulates the parenchyma to abnormal activity and is thus indirectly responsible for the hyperthyroidism with its attendant symptoms. Although the great majority of hypertrophic thyroid glands are not tuberculous, any infection which may even in a few instances be an etiologic factor is of interest in dealing with a disease the cause of which is so shrouded in mystery." As far back as 1905 Costa, and later Dumas, and Hufnagel, suggested that exophthalmic goitre represents a tuberculous process in the thyroid gland. Uemura,⁷⁸ in 1917, again raised the question in regard to the relationship between tuberculosis and the genesis of exophthalmic goitre. Mosiman,⁵⁵ the same year, brought out the striking association between hyperthyroidism and tuberculosis of the thyroid gland. Plummer and Broders, in 1920, further stressed this association and reported hyperthyroidism in five of their seven cases. On the other hand, Collier and Huggins,¹⁸ in 1926, stated their belief that the view that tuberculosis stimulates the gland to abnormal activity is untenable. This opinion was based on a study of one of their cases, which apparently indicated that there was no appreciable effect on the parenchymatous hypertrophy or its activity by the development of miliary tubercles in the gland, and because the parenchyma of the experimental tuberculous glands in animals was not stimulated to a hyperplastic state. There have been instances, however, in which such changes have been noted in experimental animals, notably in the experiments conducted by de Quervain, and which have been considered elsewhere. These authors are inclined to believe that the presence of tuberculosis in the hyperplastic type of gland is a coincidence. In fifteen of our twenty-one cases there were clean-cut evidences of hyperthyroidism, and in eight cases there was simultaneous microscopical evidence of tuberculosis and parenchymatous hyperplasia, yet it was impossible for us to reach a definite conclusion in regard to whether the tuberculosis preceded the hyperthyroidism and the hyperplasia or if the converse was true.

A distinction must be made between tuberculous infection of the thyroid gland and the so-called sclerosing tuberculosis of the French authors, which is said to occur secondarily to pulmonary tuberculosis. There is practically

nothing known of the pathological changes in the thyroid gland in the early stages of pulmonary tuberculosis, since thyroidectomy was seldom done during this period. Yet it is in this early stage that symptoms of thyroid disturbances are most commonly encountered. On the other hand, there is an abundance of necropsy evidence, chiefly in the French literature, of the occurrence of marked sclerosis in the thyroid glands of patients who died from pulmonary involvement. It is generally agreed that this type of lesion is a consequence of toxæmia, incident to advanced pulmonary tuberculosis rather than to a bacillary invasion. Further evidence that the process is not a direct result of the bacillus of tuberculosis is the lack of characteristic histological evidence of tuberculosis and the failure of investigators to recover the organisms from such glands. The sclerosis described by Budd and Williams,¹² in which typical tubercles containing giant cells were observed, is an entirely different condition. We encountered this form of reaction to the direct invasion of the gland by the bacillus on several occasions.

Pathology.—A diffuse miliary process was the most common observation in our cases; this form was diagnosed microscopically in seventeen cases. (Figs. 1 to 7.) It is likewise the most common form reported in the literature. A distinction must be made between miliary involvement of the thyroid gland as part of a generalized fatal tuberculosis in which all the organs are more or less riddled with tubercles, and a similar process in which there is also tuberculous bacillæmia, but in which the disease localizes in the thyroid gland without fatal outcome. The tubercles in the thyroid gland are not dissimilar to tubercles in other organs. They have been described as being interacinar and intra-acinar, the former occurrence being more common. We noted both forms as well as a combination of the two. An abundance of giant cells is the rule although it may be difficult or impossible to find them. This is particularly true when there is a tendency toward healing within the tubercles. This tendency is probably more common than the tendency toward progression of the disease. We have noted various stages of the healing of tubercles in glands which also showed areas in which the tubercles revealed no evidences of healing. Less frequently conglomerate tubercles are encountered which evidently have formed from the union of discrete tubercles. Subsequently caseation may develop within these masses, and these in turn may eventually break down into cold abscesses. Such progression of the disease, however, is extremely rare. Still rare, but somewhat more common, is the development of considerable fibrous tissue as a reaction to the infection present within the thyroid gland. This type of gland is liable to be small and firm and will give rise clinically to a suspicion of thyroiditis or malignancy. We encountered four such glands, two of which were slightly larger than normal, whereas the other two represented normal or slightly smaller glands. In the earlier stages before most of the glandular tissue is destroyed one is likely to encounter well-formed tubercles, but as the process advances there is practically nothing remaining but firm, tightly woven fibrous tissue in which an occasional tubercle or giant cell

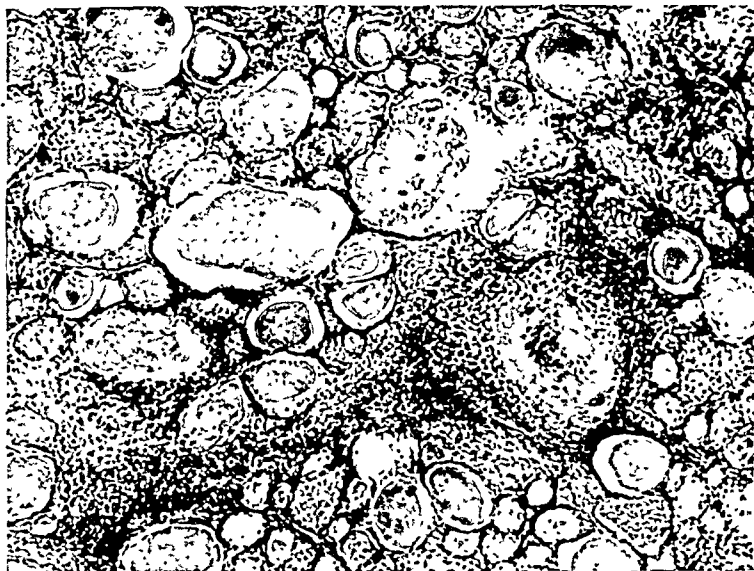


FIG. 1.

FIG. 1.—Early diffuse tuberculous thyroiditis of the isthmus in a colloid thyroid gland; multiple tubercles with many large giant cells; marked round-cell infiltration.

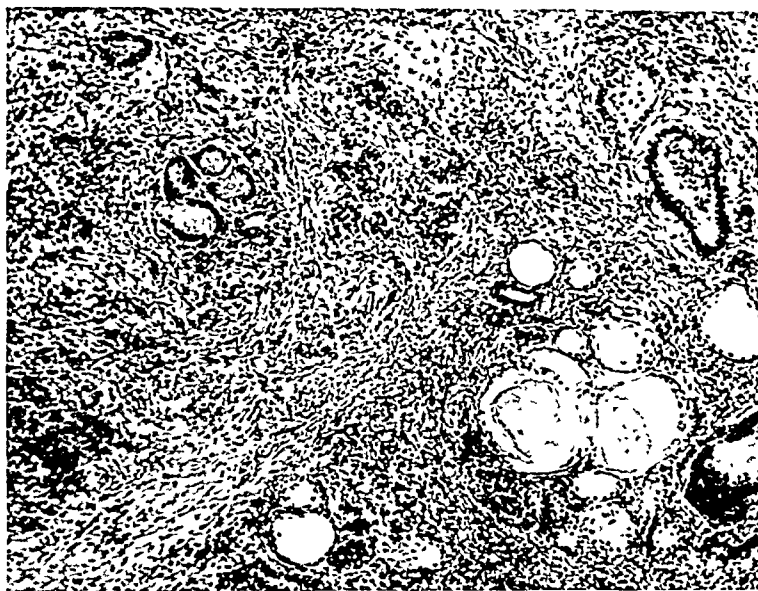


FIG. 2.

FIG. 2.—Diffuse tuberculous thyroiditis; tubercles with many giant cells and moderate fibrosis.

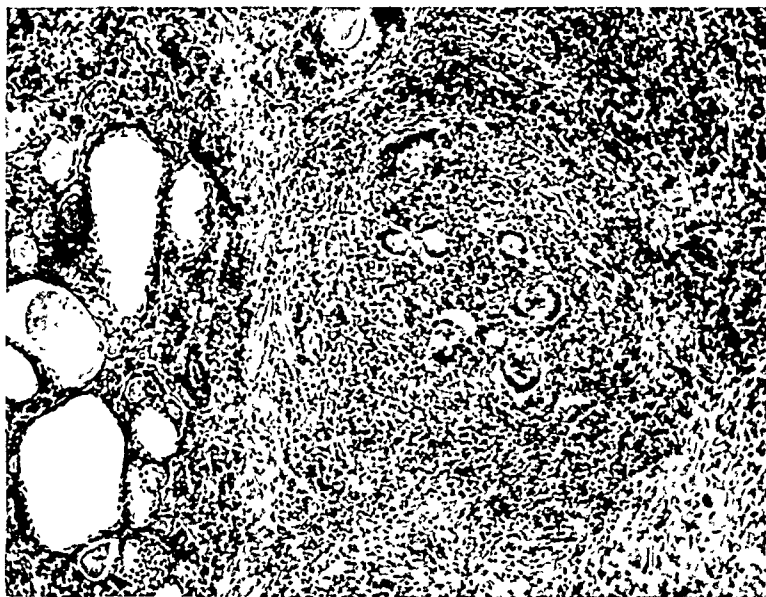


FIG. 3.

FIG. 3.—Diffuse miliary tuberculosis in colloid thyroid gland; tubercle containing many giant cells; moderate fibrosis and round-cell infiltration.

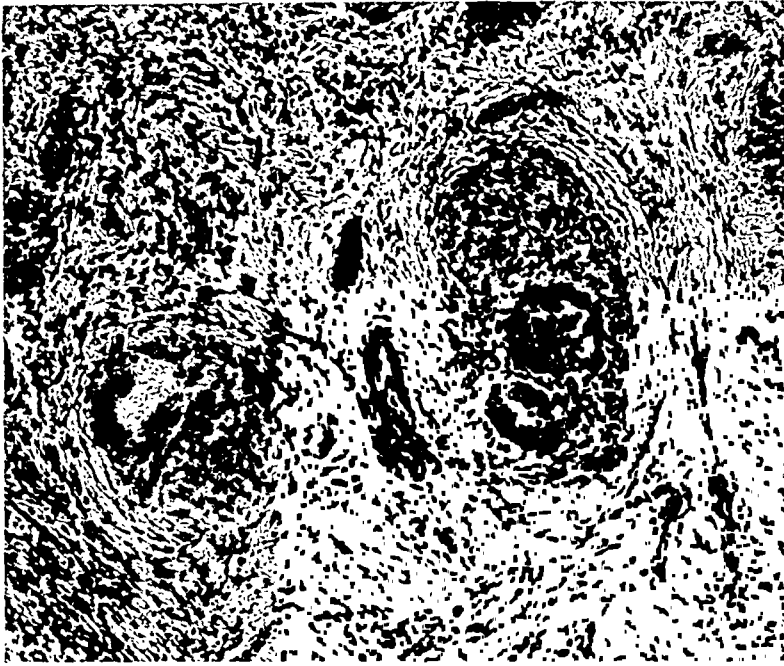


FIG. 4.

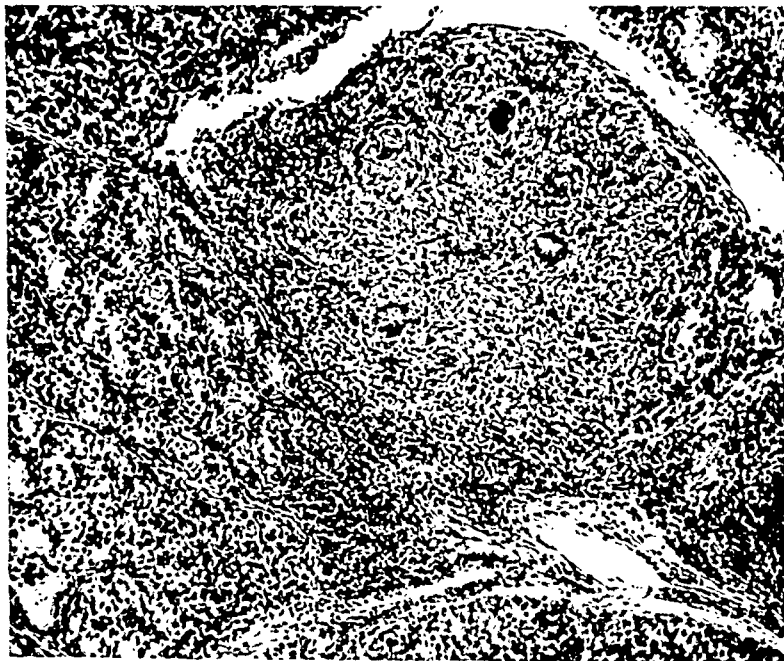


FIG. 5.

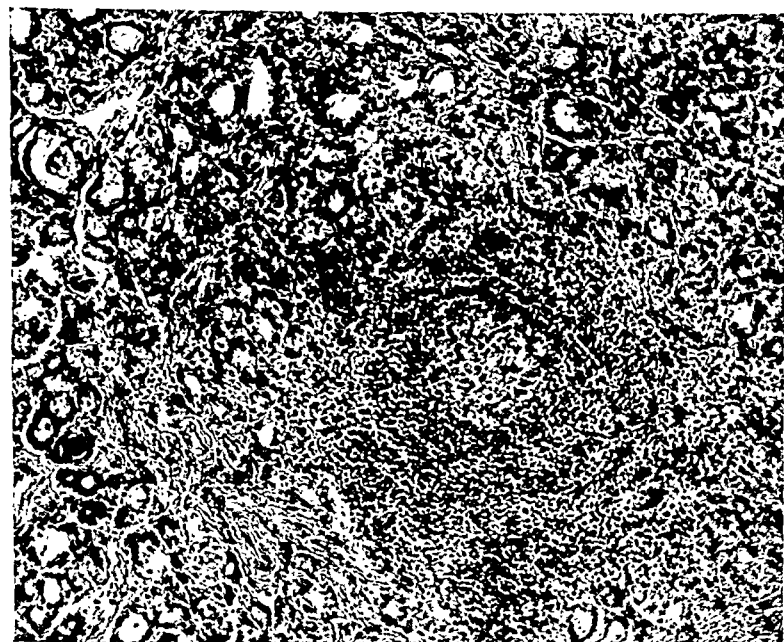


FIG. 6.

FIG. 4.—Diffuse miliary tuberculosis in an adenomatous thyroid gland; fibrosis marked. Very little gland tissue remains.
 FIG. 5.—Diffuse miliary tuberculosis in a hypertrophic parenchymatous thyroid gland; tubercle containing numerous small giant cells.
 FIG. 6.—Diffuse miliary tuberculosis in an adenomatous and hypertrophic parenchymatous thyroid gland; multiple areas of necrosis with but few giant cells.

may be discerned. (Fig. 4.) Each form of lesion as depicted here probably represents a progressive stage in the development of a single process which begins as one or more discrete miliary tubercles, and, depending on the natural or acquired resistance of the individual and the virulence of the organism, there is either a tendency toward healing or else toward progression of the disease which may stop at any stage or go on to the formation of abscess.

An entirely different type of lesion is the sclerosing tuberculosis mentioned by French authors which has been considered elsewhere. This condition is thought to be due to the presence in the blood-stream of tuberculous toxins in cases of advanced pulmonary involvement. The specific lesion caused by bacillus of tuberculosis is never found, nor has anyone ever been



FIG. 7.—Tuberculosis in an adenomatous thyroid gland; tubercle containing an enormous giant cell.

able to isolate the bacillus itself in such cases. Failure to demonstrate bacillus of tuberculosis in the tissue has not in the past prevented a diagnosis of tuberculosis of the thyroid gland if the histological picture was characteristic. Hedinger³⁵ was particularly successful in his ability to demonstrate the organism in tissue, noting them in nine of ten cases. He was in agreement, however, with Lediard,⁴⁸ Ruppner,⁶⁹ Corner,¹⁹ Halstead,³³ Arnd and others who felt that a satisfactory diagnosis could be made from the histological picture. Mosiman, and Plummer and Broders, and most of the subsequent investigators have continued to accept the histological evidence as the diagnostic criterion.

SUMMARY AND CONCLUSIONS

Tuberculosis of the thyroid gland has been considered historically and statistically. Although reports of involvement of the thyroid gland demon-

TUBERCULOSIS OF THE THYROID GLAND

strated at necropsy following deaths from general miliary tuberculosis are of academic value, we have confined our statistical study to clinical cases. The incidence of clinical tuberculosis of the thyroid gland has been shown to be extremely low; in the course of microscopical study of 20,758 thyroid glands removed surgically at The Mayo Clinic over a period of eleven years, tuberculosis was diagnosed in twenty-one, an incidence of approximately 0.1 per cent.

One hundred four cases of surgically treated tuberculosis of the thyroid gland reported in the literature, and twenty-one cases from The Mayo Clinic were tabulated separately. The combined data revealed a marked predominance of women patients evenly distributed over the fourth and fifth decades. Although evidence of active tuberculosis was present in only six of 125 cases and suspected in five others, the prevailing opinion is that probably all cases are secondary to some disease process elsewhere in the body. Diagnosis prior to microscopical study of tissue removed at operation is extremely rare; only three such instances are recorded. It was impossible from a detailed study of our data on twenty-one cases to determine criteria by which a clinical diagnosis could be made. The principal syndrome exhibited by these patients was that of hyperthyroidism, which was noted in fifteen cases, with an increased basal metabolic rate of +19 per cent. or higher. Moreover, the question of whether the hypertrophic gland is rendered more susceptible to invasion by the bacillus of tuberculosis or the infection stimulates the parenchyma to abnormal activity, and is thus indirectly responsible for the hyperthyroidism, could not be conclusively determined.

Evidence of thyroid deficiency was noted after thyroidectomy in only three of 115 cases. Diffuse miliary tuberculosis, in which there were typical epithelioid tubercles and giant cells, was by far the most common observation; caseation was reported in about a fifth of the cases studied; abscess, and evidences of marked sclerosis, were less frequently noted. Tuberculosis occurred in an adenomatous goitre in fifty-one cases, in a hypertrophic parenchymatous gland in thirty-one cases, and in a colloid gland in six cases. Convalescence after thyroidectomy in these cases was not different from that of cases of uncomplicated adenomatous or exophthalmic goitre, and, as in these, the same excellent prognosis can be given.

BIBLIOGRAPHY

- ¹ Albers: Quoted by Nather.
- ² Apelt, F.: Ein Fall von Basedowscher Krankheit im Anschluss an Nichteitriges Thyreoiditis acuta. München. med. Wchnschr., vol. ii, pp. 2136-2137, October 13, 1908.
- ³ Arnd, C.: Beiträge zur Klinik der Schilddrüsentuberkulose. Deutsch. Ztschr. f. Chir., vol. cxvi, pp. 7-28, 1912.
- ⁴ Aschoff: Quoted by Nather.
- ⁵ Aubriot, P.: Formes chirurgicales de la tuberculose thyroïdienne. Presse méd., vol. ii, pp. 1207-1209, September 9, 1925.
- ⁶ Barth, H.: Un cas de thyroïdite caséeuse, affectant la forme du goitre suffocant. France méd., vol. i, pp. 549-554, 1884.
- ⁷ Baumgarten: Quoted by Nather.

- ⁸ Bérard: Quoted by Mosiman.
- ⁹ Berry, James: VII. Diseases, etc., of the Ductless Glands. I. On the Pathology of Goitre and Some Other Diseases of the Thyroid Gland. Tr. Path. Soc., London, vol. xli, pp. 258-269, 1890.
- ¹⁰ Borri, C.: Di un caso di tubercolosi della glandula tiroide. Morgagni, vol. lxvi, pp. 1256-1260, 1924.
- ¹¹ Bruns, P.: Struma Tuberculosa. Beitr. z. klin. Chir., vol. x, pp. 1-12, April, 1893.
- ¹² Budd, S. W., and Williams, Carrington: Tuberculosis of the Thyroid Gland: Report of Cases. Jour. Am. Med. Assn., vol. xcii, pp. 1741-1744, May 25, 1929.
- ¹³ Camera, U.: La tubercolosi primitiva della ghiandola tiroide. Clin. Chir., vol. xx, pp. 1897-1912, 1912.
- ¹⁴ Charrin, and Nattan-Larrier: Lésions constatées chez des nouveau-nés non tuberculeux mais issus de mères tuberculeuses. Compt. rend. Soc. de biol., vol. 1, pp. 1025-1026, November 12, 1898.
- ¹⁵ Chiari, H.: Ueber Tuberculose der Schilddrüse. Med. Jahrb., pp. 68-75, 1878.
- ¹⁶ Clairmont, Paul: Zur Tuberculose der Schilddrüse. Wien. klin. Wchnschr., vol. xv, pp. 1267-1270, November 27, 1902.
- ¹⁷ Cohnheim, J.: Ueber die Tuberculose der Chorioidea. Virchow's Arch. f. path. Anat. u. Physiol., vol. xxxix, pp. 49-69, 1867.
- ¹⁸ Collier, F. A., and Huggins, C. B.: Tuberculosis of the Thyroid Gland. ANNALS OF SURGERY, vol. lxxxiv, pp. 804-820, December, 1926.
- ¹⁹ Corner, E. M.: Primary and Secondary Local Tuberculosis of the Thyroid Gland. Tr. Clin. Soc., London, vol. xxxvii, pp. 112-114, 1904.
- ²⁰ Cornil, and Ranvier: Quoted by Mosiman.
- ²¹ Costa, C. A.: Tuberculose inflammatoire. Goitres d'origine tuberculeuse. Lyon, 71 pp., 1905.
- ²² Creite: Ueber tuberkulöse Strumen. Beitr. z. klin. Chir., vol. lxxviii, pp. 487-495, 1912.
- ²³ Cruveilhier: Quoted by Nather.
- ²⁴ Demme, R.: Die Krankheiten der Schilddrüse. In: Gerhardt, C.: Handbuch der Kinderkrankheiten, pt. 2, vol. iii, pp. 337-420, Tuebingen, 1878.
- ²⁵ Dumas: Quoted by Arnd.
- ²⁶ Dunger, Reinhold: Ueber akute nichteitrige Thyreoiditis. München. med. Wchnschr., vol. ii, pp. 1879-1883, September 8, 1908.
- ²⁷ Eiselsberg: Quoted by Nather.
- ²⁸ Ewald: Quoted by Nather.
- ²⁹ Fraenkel, Eugen: Ueber Schilddrüsentuberculose. Virchow's Arch. f. path. Anat. u. Physiol., vol. civ, pp. 58-72, 1886.
- ³⁰ Frassi, Luigi: Weiterer Beitrag zur Kenntnis der Tuberculose der Glandula thyreoidea. Deutsch. Ztschr. f. Chir., vol. ccxiii, pp. 416-421, January, 1929.
- ³¹ Frederiksen, J., and Portman, A.: Case of Miliary Tuberculosis in Adenomatous Thyroid Gland. Hospitalstidende, vol. lxxii, pp. 1286-1293, December 19, 1929.
- ³² Gloyne, S. R.: The Thyroid in Experimental Tuberculosis. Jour. Path. and Bacteriol., vol. xxviii, pp. 451-456, 1925.
- ³³ Halstead, A. E.: Tuberculosis of the Thyroid Gland, with Report of a Case. Internat. Clin., s. 20, vol. i, pp. 120-125, 1910.
- ³⁴ Hamburger: Quoted by Arnd.
- ³⁵ Heding, E.: Zur Lehre der Schilddrüsentuberculose. Deutsch. Ztschr. f. Chir., vol. cxvi, pp. 125-139, 1912.
- ³⁶ Hegar, A.: Die Tuberculose der Schilddrüse. Kiel, 1891.
- ³⁷ Heschl: Quoted by Nather.
- ³⁸ Higgins, C. C.: Tuberculosis of the Thyroid Gland with Report of Five Cases. Internat. Clin., s. 36, vol. iv, pp. 269-275, December, 1926.
- ³⁹ Hofhauser, J.: Basedowsche Krankheit und Schilddrüsentuberculose. Arch. f. klin. Chir., vol. clxiii, pp. 319-328, 1930.

TUBERCULOSIS OF THE THYROID GLAND

- ⁴⁰ Hufnagel, Viktor: Basedow im anchluss an tuberculöse Erkrankungen. München, med. Wchnschr., vol. ii, p. 2392, November 17, 1908.
- ⁴¹ Jean, G.: Tuberculose du corps thyroïde. Ann. d'anat. path. méd.-Chir., vol. iii, p. 761, 1926.
- ⁴² Kashiwamura, Sadaichi: Die Schilddrüse bei Infektions-krankheiten. Virchow's Arch. f. path. Anat. u. Physiol., vol. clxvi, pp. 373-385, 1901.
- ⁴³ Kaufmann: Quoted by Mosiman.
- ⁴⁴ Kipp, H. A.: Tuberculosis of the Thyroid. Pennsylvania Med. Jour., vol xxxii, pp. 496-497, April, 1929.
- ⁴⁵ Krafft, H. C.: Thyroidites tuberculeuse. Rev. méd. de la Suisse., vol. xlix, pp. 562-564, August 25, 1929.
- ⁴⁶ Langerhans: Quoted by Mosiman.
- ⁴⁷ Lebert, H.: Die Krankheiten der Schilddrüse und ihre Behandlung, p. 264, Breslau, 1862.
- ⁴⁸ Lediard, H. A.: Primary Tuberculosis of the Thyroid. Tr. Path. Soc., London, vol. lvii, pp. 153-154, 1905.
- ⁴⁹ Lenormant: La tuberculose du corps thyroïde à propos d'un cas d'abcès froid thyroïdien. Progrès méd., s. 3, vol. xxiv, p. 445, 1908.
- ⁵⁰ Lorand: Quoted by Nather.
- ⁵¹ Mackenzie: Quoted by Gloyne.
- ⁵² Marcuse, Erich: Beitrag zur Schilddrüsentuberkulose. Med. Klin., vol. i, pp. 775-776, May, 1928.
- ⁵³ Meyer, R.: Beitrag zur Schilddrüsentuberkulose. Zentralbl. f. Chir., vol. lviii, pp. 1689-1693, July 4, 1931.
- ⁵⁴ Morin: Physiologie et médication thyroïdiennes. Rev. méd. de la Suisse, pp. 241-250, May 20, 1895.
- ⁵⁵ Mosiman, R. E.: Tuberculosis of the Thyroid. Surg., Gynec., and Obst., vol. xxiv, pp. 680-693, June, 1917.
- ⁵⁶ Nather, Karl: Zur Pathologie der Schilddrüsentuberkulose. Mitt. a. d. Grenzgeb. d. Med. u. Chir., vol. xxxiii, pp. 375-404, 1921; Abstr. in: Jour. Am. Med. Assn., vol. lxxvii, p. 898, September 10; p. 979, September 17, 1921.
- ⁵⁷ Perry, E. C.: II. Tuberculosis of the Thyroid Gland. Tr. Path. Soc., London, vol. xlii, p. 298, 1890.
- ⁵⁸ Plummer, W. A., and Broders, A. C.: Tuberculosis of the Thyroid. Minnesota Med., vol. iii, pp. 279-283, June, 1920.
- ⁵⁹ Pollag: Quoted by Collier and Huggins.
- ⁶⁰ Pöncet, A., and Keriche, R.: Tuberculose inflammatoire thyroïde. Bull. de l'Acad. de méd., vol. lxii, pp. 615-626, 1909.
- ⁶¹ Pupovac, Dominils: Zur Kenntnis Tuberkulose der Schilddrüse. Wien. klin. Wchnschr., vol. xvi, pp. 1012-1014, September 3, 1903.
- ⁶² de Quervain, F.: Thyreoiditis simplex und toxische Reaktion der Schilddrüse. Mitt. a. d. Grenzgeb. d. Med. u. Chir., vol. xv, pp. 297-304, 1905.
- ⁶³ Quinlan: Tubercular Disease of the Thyroid Gland. Irish Hosp. Gaz., vol. i, p. 141, 1873; Proc. Path. Soc. Dublin, n.s., vol. v, p. 258, 1871-1873, 1874.
- ⁶⁴ Rendleman, W. H., and Marker, J. I.: A Case of Tuberculosis, Primary in the Thyroid. Jour. Am. Med. Assn., vol. lxxvi, pp. 306-307, January 29, 1921.
- ⁶⁵ Ribbert: Quoted by Mosiman.
- ⁶⁶ Rindfleisch: Quoted by Mosiman.
- ⁶⁷ Roger, H., and Garnier, M.: Des lésions de la glande thyroïde dans la tuberculose. Arch. gén. de méd., vol. clxxxv, pp. 385-414, 1900.
- ⁶⁸ Rokitanski: Quoted by Mosiman.
- ⁶⁹ Ruppanner, Ernst: Über tuberculöse Strumen; ein Beitrag zur Kenntnis der Schilddrüsentuberkulose. Frankfurter Ztschr. f. Path., vol. ii, pp. 513-547, 1909.

- ⁷⁰ v. Schiller, Karl: Kalter Abszess in der Glandula thyreoidea. *Wien. klin. Wchenschr.*, vol. ii, pp. 1088-1090, July 23, 1908.
- ⁷¹ Schmaus: Quoted by Mosiman.
- ⁷² Schwarz: Quoted by Corner.
- ⁷³ Shimodiara, Yosai: Experimentelle Untersuchungen über die tuberkulose-infektion der Schilddrüse. *Deutsch. Ztschr. f. Chir.*, vol. cix, pp. 443-479, May, 1911.
- ⁷⁴ Smith, L. W., and Leech, J. V.: Tuberculosis of the Thyroid. *Surg. Clin. N. Amer.*, vol. viii, pp. 185-194, February, 1928.
- ⁷⁵ Tixier, L., and Savy, P.: Tuberculose thyroïdienne folliculaire à forme de thyroidite ligneuse. *Lyon chir.*, vol. ix, pp. 367-377, April, 1, 1913.
- ⁷⁶ Tomellini, Luigi: Experimentelle Untersuchungen über die Tuberkulose der Schilddrüse. *Beitr. z. path. Anat. u. z. allg. Path.*, vol. xxxvii, pp. 590-624, 1905.
- ⁷⁷ Torri, Odoacre: La tiroide nei morbi infettivi. *Policlinico (sez. chir.)*, vol. vii, pp. 145-164, March 15, 1900.
- ⁷⁸ Uemura, Shunji: Über Tuberkulose der Schilddrüse mit besonderer Berücksichtigung der Tuberkulose in Basedowschilddrüsen. *Deutsch. Ztschr. f. Chir.*, vol. cxl, pp. 242-274, May, 1917.
- ⁷⁹ Villata, G.: Sopra un caso di tubercolosi della ghiandola tiroide. *Minerva med.*, vol. ii, pp. 1012-1016, December, 1929.
- ⁸⁰ Virchow: Quoted by Mosiman.
- ⁸¹ Voelcker, Arthur: Tuberculosis of the Thyroid Gland. *Tr. Path. Soc., London*, vol. xlii, p. 298, 1890.
- ⁸² Wagner: Quoted by Nather.
- ⁸³ Weigert: Zur Lehre von der Tuberkulose und Verwandten Erkrankungen. *Virchow's Arch. f. path. Anat. u. Physiol.*, vol. lxxvii, pp. 269-298, August, 1879.
- ⁸⁴ Wölfler, A.: Tuberkulose der Schilddrüse. *Arch. f. klin. Chir.*, vol. xxix, pp. 826-828, 1883.
- ⁸⁵ Ziegler: Quoted by Mosiman.⁶⁵

DISCUSSION.—DR. MARTIN B. TINKER (Ithaca, N. Y.) said that Doctor Rankin's paper had brought out points that have come in the experience of most surgeons who have had similar cases: First, that the diagnosis of tuberculosis of the thyroid is difficult but not impossible before operation; second, that on the operating table appearances are more likely to suggest simple thyroiditis, rather than tuberculosis; and third, that these cases are quite readily curable.

In certain instances the condition may be of great gravity: his first case, diagnosed by Doctor Bloodgood, of Johns Hopkins, as "tuberculosis of the thyroid," came on a stretcher in rather a precarious condition. He was a physician then practicing in Little Falls, New York, but is now President of a State Medical Society in the Southwest, where he went for his health after recovery from his operation. His extreme prostration was apparently attributable to the thyroid condition, not tuberculosis which affected simultaneously other organs of the body, for he recovered promptly after thyroidectomy, is now perfectly well and doing a large practice.

A certain number of these patients need much the same rest, dietetic and climatic treatment advised for patients with tuberculosis of other organs of the body.

DR. ALEXIS V. MOSHCOWITZ (New York City) said that his experience with this variant of tuberculosis or this form of thyroiditis is limited to two cases. One of these is particularly interesting. A man on a visit to New York City was suddenly taken acutely ill with a very high temperature. He was seen in consultation by a number of physicians. The outstanding features of his illness were a swelling of the right lobe of the thyroid gland and hyperpyrexia up to 106°F. When seen by Doctor Moschcowitz, the physical signs and symptoms above-mentioned were still present. He therefore diagnosed a deep suppurative thyroiditis and advised urgent operation. Preliminary

TUBERCULOSIS OF THE THYROID GLAND

aspiration failed, however, to reveal the presence of pus. Because of the pressure upon the trachea, operation was proceeded with. Exposure of the right lobe of the thyroid gland showed it to be exceedingly hard, typical of a Riedel's eisenharte Struma. The greater portion of the right lobe of the thyroid gland was excised piecemeal and practically without any bleeding; the patient made an uninterrupted recovery. Doctor Mandelbaum, pathologist to Mt. Sinai Hospital, reported the specimen as one of tuberculosis. The case healed so kindly, however, that Doctor Moschcowitz is still inclined to doubt somewhat the correctness of the pathological diagnosis.

DR. GEORGE W. CRILE (Cleveland) said that in eighty-six cases they had deliberately performed thyroidectomy in the presence of tuberculosis of the lungs on the ground that the patients had two diseases. Sufficient time has not elapsed since these operations to determine the end-results except to say that all are greatly improved. In no one of the eighty-six cases was there any tuberculosis of the thyroid gland.

DR. JOHN DOUGLAS (New York City) commented on the statement of Doctor Rankin that in the after-course of his patients there was only one thing in any way characteristic, the rather profuse discharge of serum. Doctor Douglas operated on a case of tuberculosis of the thyroid about a year ago. He did not make the diagnosis before or at the operation, and the only thing which was particularly characteristic or unusual about this case was the fact that the woman had symptoms, particularly an increased metabolic rate which was out of all proportion to the size of the thyroid. She had a comparatively small gland, not adenomatous but of the hyperplastic type. If this was a toxic thyroid with such a small increase in size, it must be necessary to take out a rather large amount of the gland in order to remove the toxic symptoms. He did a rather complete subtotal thyroidectomy. To his surprise he received a report of tuberculosis of the thyroid gland. The only after-result was not a very¹ profuse discharge of serum from the wound, but a very considerable amount of induration in the woman's neck in the region of the scar for many weeks longer than one would expect after an ordinary thyroidectomy. While she did not have a high temperature of a post-thyroidectomy form, she persisted around 101° for a long time. Most of these symptoms could be explained by the fact that it was a tuberculous infection with some absorption of the toxin following the operation. He asked whether there was a marked induration, and whether there was a prolonged high temperature in Doctor Rankin's cases.

DR. WILLIAM F. RIENHOFF, JR. (Baltimore), remarked that of course thyroiditis in this form is a chronic inflammation and one would expect a chronic inflammatory reaction in the tissues to whatever agent is producing the chronic thyroiditis. In other words, if these cases are primarily tuberculosis of the thyroid it is after all a chronic infectious process which will produce a chronic inflammatory reaction. It is only logical to assume, however, that if some other agent can be used other than the tubercle bacillus to produce a similar chronic inflammatory reaction the cytological response might be very similar to that caused by the tubercle bacillus. They have found this to be a fact and injections of paraffin and agar-agar into the thyroid glands of guinea-pigs and dogs have been followed by a cytological reaction in many ways quite similar objectively to that cytological reaction produced by the tubercle bacillus. In other words, there have been giant cells in an area surrounded by epithelioid and small round-cell infiltrations. Of course in the latter experiments the tubercle bacillus was not present and therefore one can conclude that the presence of a cellular reaction which is similar, histologically, to that seen in tuberculosis is not pathognomonic of the disease tuberculosis, and therefore, unless tubercle bacilli have been demonstrated either by staining or by putting some of the tissues in a guinea-pig with the pig developing tuberculosis later, one really cannot conclude that this type of chronic thyroiditis is tuberculous. He wondered if Doctor Rankin had, in these cases, been able to demon-

strate the tubercle bacilli. He had had similar cases in Baltimore which looked, histologically, very much like tuberculous thyroiditis but in which cases they had been unable to show, either by staining or the use of guinea-pigs, that the infection was tuberculous. He personally believed that some degenerative process which will allow the colloid to escape from the follicle into the interfollicular spaces will produce a foreign body reaction and an inflammatory reaction very similar to that produced by agar-agar and paraffin. They are at the present time attempting to prove this point. Certainly one can say that the cytological reaction seen in tuberculous lesions is not pathognomonic of the disease tuberculosis.

This controversy, as to what constitutes tuberculosis of the thyroid gland, has been going on ever since Riedel, in 1896, described chronic ideopathic thyroiditis, ligneus thyroiditis, or Riedel's struma. It has often been called tuberculosis of the thyroid gland and also carcinoma of the thyroid gland. The earlier stages of this condition of thyroiditis were described by Hashimoto, in 1912, who called this condition "struma lymphomatosa." Riedel described the late stages.

For some years there was a prolific discussion as to the etiological factors and a great many of the French observers thought this was a syphilitic thyroiditis, and others thought it was a tuberculous thyroiditis, but the specific organisms could never be demonstrated.

DR. FRED W. RANKIN, answering the question as to convalescence following thyroidectomy when tuberculosis of the thyroid has been observed, said that in their group of cases there had been no difference from the usual standardized type except for the prolonged drainage which he had mentioned. The drainage was of the profuse, watery type, which they had not noticed following thyroidectomies for other reasons. Infiltration of the wound had not been observed in any of these twenty-one cases. He should be inclined to think that it was secondary to some type of infection, such as is occasionally seen in goitre wounds following operation for hyperplastic goitre.

He thought Doctor Crile's point to be very well taken, namely, that the hyperthyroidism should be operated on in the presence of the pulmonary tuberculosis under certain conditions. They too have operated on a number of patients who had a co-existing pulmonary lesion and hyperthyroidism. The outcome of these cases he did not know in detail at present but he felt it a sound principle to eliminate a semi-acute condition in order to influence favorably the chronic pulmonary lesion.

Relative to Doctor Reinhoff's question as to whether or not they had been able to substantiate the pathological diagnosis of tuberculosis of the thyroid gland by staining specimens or by injection into guinea-pigs, they had not. Their pathologists had depended on the characteristic microscopical picture, as evidenced by the presence of epithelioid and giant cells, and had felt that this was sufficient to warrant the hypothesis of tuberculosis in the thyroid gland as a clinical entity. They had not been able to stain the specimens and obtain the tubercle bacillus and they had not tried animal injection. He thought there is unnecessary confusion about this type of diagnosis. He believed pathologists are willing to accept the diagnosis of tuberculosis of the thyroid without all of the above-mentioned data. Unquestionably, tuberculosis of other locations, such as of the kidney or spleen, is diagnosed on such a picture in certain cases, without the substantiation of guinea-pig inoculation or staining.

PARATHYROIDISM
BY MAX BALLIN, M.D.
OF DETROIT, MICH.

AT THE meeting of the American Surgical Association in 1931 I made a communication on parathyroidism and parathyroidectomy based on about twenty-five cases of parathyroidectomies published in the literature, sixteen personal observations, and fifty autopsies in the literature where skeletal changes were found with parathyroid tumors.

These numbers have increased considerably during the year. Over fifty parathyroidectomies for osteomalacic conditions have now been published besides the seventy parathyroidectomies for ankylosing polyarthrititis reported from Oppel's clinic in 1928. Our own experience has increased to forty-five cases of such operations. Numerous autopsies showing the coincidence of parathyroid tumors with osteomalacia have been added (Brines, Hartman, *et al.*). Wherever the condition becomes known, the diagnosis is made quite frequently. To my knowledge, in Detroit, where the subject of parathyroidism has been discussed a good deal, four surgeons have done parathyroidectomies. Dr. Wm. H. Gordon, of Harper Hospital, has, within the past year, diagnosed parathyroidism eight times in his private practice and in our Out-Patient Department. Dr. R. V. Funston, of the orthopædic department at Harper Hospital, has diagnosed the condition so frequently that he has sent eight cases for parathyroidectomy and considers this chapter a valuable addition to orthopædic work. From each of the cities where my colleagues, especially Dr. Plinn Morse, have read papers on the subject, we always receive X-ray films of one or more patients, and sometimes the patients themselves are sent with the condition well established. Dr. A. A. Mertz and Dr. C. H. Tearnan, of Decatur, Illinois, realized after hearing one of Doctor Morse's papers that they had four such patients, under observation a long time, without a diagnosis being made. Two of them, very advanced cases, we operated upon with striking results; and up to now they themselves have operated upon four more. It is interesting how these colleagues, as well as others, recall that they have invalid patients who have been sitting in chairs or lying in bed for years, and now on re-examination they make the diagnosis and treat the patient for parathyroidism. I have gone into this a little too elaborately, perhaps, but it seems to be simply a matter of becoming acquainted with the entity to find plenty of cases. To be sure, a larger experience is still needed to draw more definite conclusions as to the extent of the parathyroidism and the variety of symptoms to be included in the entity, and to understand better the indications for medical or surgical treatment. Our diagnostic facilities have also been very much

enhanced during the year by the addition of precise methods of determining the muscular hypotonia coincident with this affection.

Of thirty-five cases tabulated from the literature by John Helström, in 1932, thirty-three showed tumors of the parathyroid, and nearly all of them had the classical bone changes of generalized osteitis fibrosa cystica. Of our forty-five cases, only twenty-two offered the same classical picture as the outstanding symptom. This comparison of the two tabulations suggests that



FIG. 1.



FIG. 2.

FIG. 1.—G. P., a woman, fifty-four years old. Fractures of clavicle, humerus and ribs for fifteen to twenty years. Back and leg ache, limping, scoliosis, two-inch loss in height, demineralization of all bones, wedging lower dorsal and fifth lumbar vertebræ; calcium fourteen milligrams, phosphorus two and one-half milligrams. Patient very weak. Parathyroidectomy, two glands removed, adenomatous. Clinically cured.

FIG. 2.—Mrs J. B., sixty years. Practically the same type of case as Fig. 1, sick four years. Calcium twelve milligrams, all X-ray signs, chronaxie .16/1000. Good clinical result from parathyroidectomy.

the surgeons whose operations Helström tabulated did parathyroidectomies only for the entity of generalized osteitis fibrosa cystica, and there can be no doubt that the skeletal complications of osteitis fibrosa cystica generalisata (von Recklinghausen's disease) are so far recognized as the main indications for parathyroidectomy. The symptoms are very clearly outlined now and consist in more or less general decalcification, the findings of osteitis fibrosa cystica; mottled appearance of the flat bones; cyst formation in the long bones; replacement of bony tissue by giant-cell tumors; spontaneous, multiple fractures; and curvatures and deformities of the long bones and spine.

PARATHYROIDISM

Besides these changes the high serum calcium with lessened serum phosphorus, the negative balance in the calcium metabolism, and the increased calcinuria are classical symptoms and indications for parathyroid investigation. Figures 1 to 4, with their legends, are illustrative of a few of the nearly 100 cases published as classical findings of parathyroidism and indications of parathyroidectomy.

But less classical symptom complexes should also be taken into con-

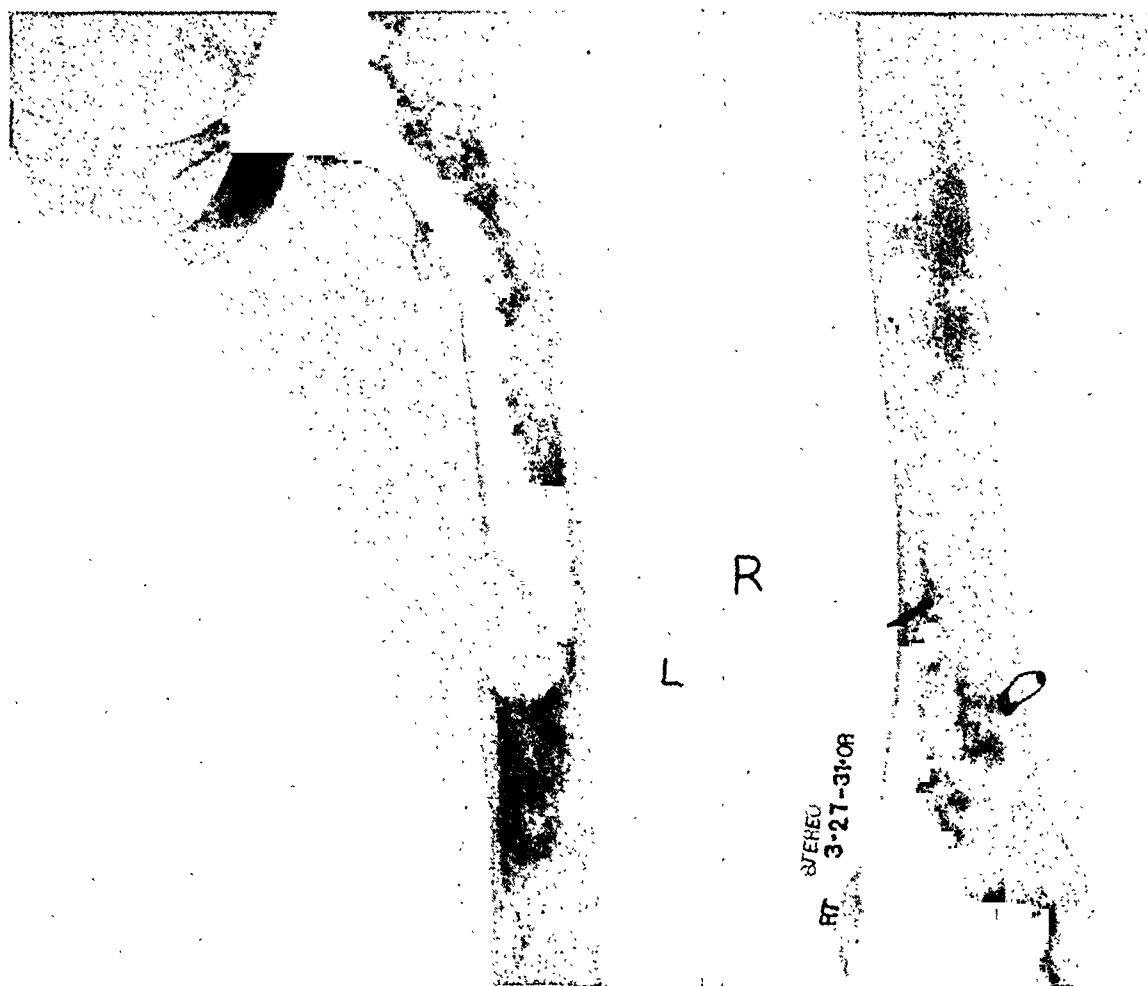


FIG. 3.

FIG. 4.

FIG. 3.—Mrs. E. W., forty-five years. The long bones in a typical case with vertebral compressions. The femur with cysts and giant-cell tumor (osteoclastoma).

FIG. 4.—Same case as Fig. 3. Small size osteoclasia, osteitis fibrosa cystica in other femur.

sideration in order to give many patients the benefit of our knowledge of parathyroidism and its medical and surgical treatment.

Besides type (1)—Classical osteitis fibrosa cystica generalisata, with vertebral compression, bone cysts, *etc.*, we will discuss (2) Paget's type, (3) arthritic type, (4) juvenile type and (5) myasthenic type.

(2) *Paget's Type*.—The question of whether Paget's disease belongs to this group and whether it can be benefited by parathyroidectomy has not as yet been settled. The opinion that Paget's disease and von Recklinghausen's disease (osteitis deformans and osteitis fibrosa cystica generalisata) are one entity is coming more and more to the front. The pathological

differentiation shows all transitory stages from one to the other. Röntgenologically, both types of the affection have been found in the same patient. D. E. Shouten, Bourguignon and Sainton, and Ballin and Morse have observed cases of osteitis fibrosa cystica with Paget's deformities. The fact that Paget's disease is followed in about 15 per cent. of the cases by sarcoma

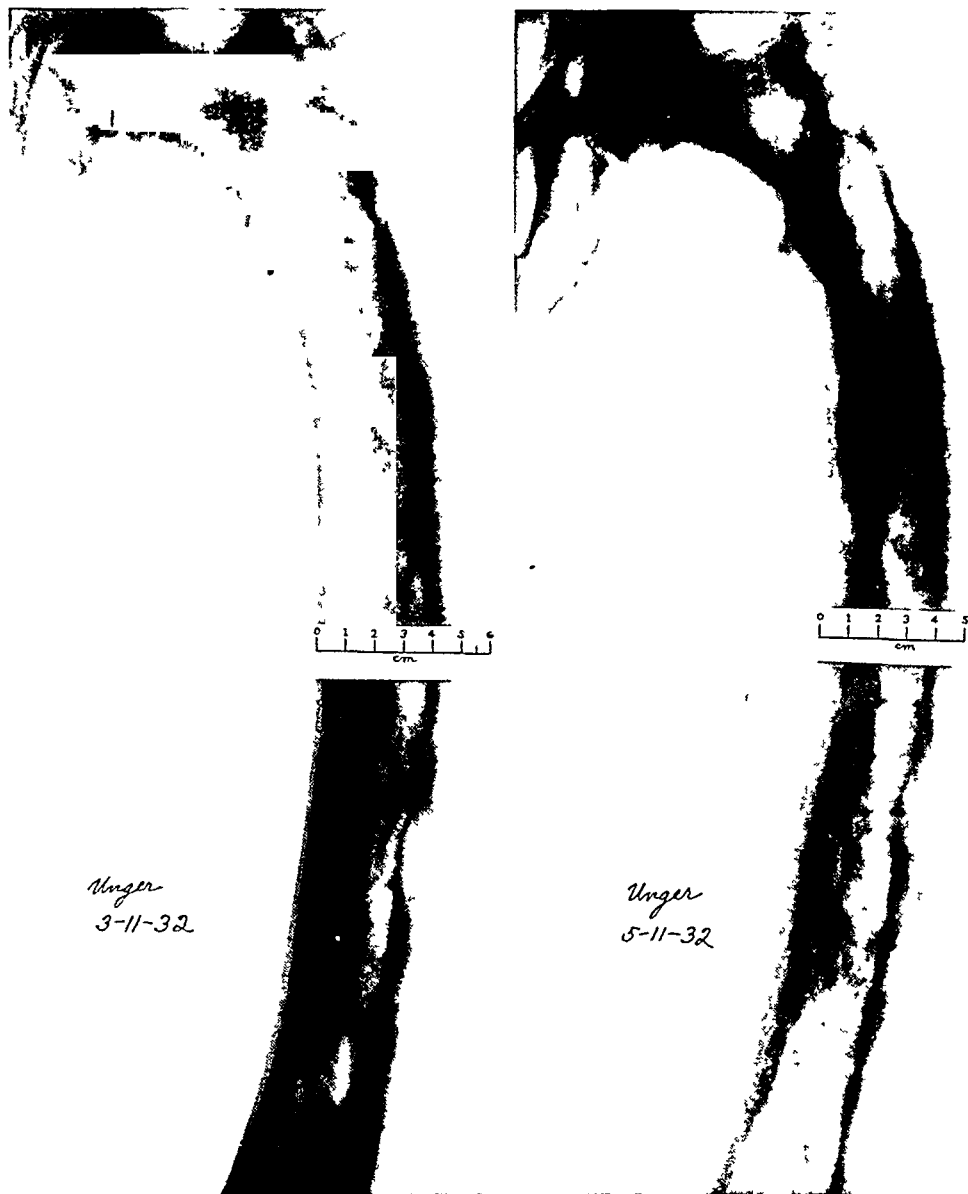


FIG 5—Mrs S B U, sixty years old. A typical monostotic Paget's disease of the femur with some improvement beginning two months after operation

is not differentiating. Malignancy has also followed osteitis fibrosa cystica. Benjamin F. Joseph reports a case of giant-cell sarcoma in a case of osteitis fibrosa cystica metastasizing into the inguinal lymph-nodes. A. Fromme also writes concerning the relation of osteitis fibrosa cystica to sarcoma. If we consider Paget's disease a form of osteitis fibrosa cystica occurring at

PARATHYROIDISM

a later age, we can easily understand why sarcoma follows oftener in Paget's than in osteitis fibrosa cystica. Clinically the symptoms of osteitis fibrosa cystica and osteitis deformans merge into each other without any striking distinction being present; the former usually runs a more rapid, painful, and the latter a more chronic course. Our therapeutic experience has taught us that the symptoms of osteitis fibrosa cystica as well as those of Paget's disease have been improved by parathyroidectomy. (See also Bourguignon and Sainton, and Bovee.) Some men try to differentiate between the monostotic type of Paget's and the polyostotic form, but such distinction is just as impossible as in monostotic cysts and multiple polyostotic cystic forms of osteitis fibrosa cystica. Again both blend into each other, and in the seemingly monostotic types of both there are usually slight changes throughout the skeleton.



FIG. 6.



FIG. 7.

FIG. 6.—V. J. T., fifty-three years old. Skull in Paget's disease before parathyroidectomy. This patient had typical Paget's disease, head grew larger, deafness, weakness and pain in limbs. Two hyperplastic parathyroids removed.

FIG. 7.—Same patient as Fig. 6, six months after operation. Note how skull has improved, especially disappearance of the fuzzy, cotton-like (nigger wool) appearance of the outer table.

Our experience with Paget's type is somewhat short in duration to warrant definite statements, but encouraging enough to stimulate further study.

CASE I.—F. T., aged sixty years, typical Paget's type. Picture presented in our last year's paper showed immense skull and large, curved, thickened tibia and femurs. Parathyroidectomy, June 24, 1931. Blood serum calcium 11.6 milligrams. Immediately after the operation the pain in his extremities was relieved to such an extent that he could walk again and become an office patient, which had been impossible for him for many months. He died, however, from cerebral symptoms, pressure on cranial nerves caused by sarcomatous changes in his Paget's skull.

CASE II.—Mrs. S. B. U. clinically had a monostotic type of Paget's disease of the femur of several years' standing. Lately there has been a good deal of pain in the limbs and back. Besides the Paget's findings there was some arthritic process. This woman had a marked parathyroid adenoma. Biopsy of the bones showed what is considered typical of Paget's disease—excessive osteoid reaction, marked osteoclasts and

hyperplasia of osteoblastic tissue. The immediate result after operation was great general improvement. The femur looks less swollen, and the patient is able to walk without pain. This report is given after two months' observation only and with some reservation. Even after this short time the X-ray shows some improvement. The fuzziness of the thickened femur has decreased, by actual measurement of the X-ray, two to three millimetres, and some normal trabeculation is returning in place of the osteogenetic tissue. (Fig. 5.)

CASE III.—V. J. T., fifty-three years old, a priest, had a typical Paget's disease for ten to fifteen years. His hat size changed from seven and one-quarter to eight and one-half and he grew five inches shorter in ten years. During the same time he became more deaf. He had become very weak in muscular strength in the last two years and had great pain in his hips. Typical Paget's disease was shown in the X-ray with a calcium reading of around eleven milligrams. After many consultations at different clinics a parathyroidectomy was performed on November 11, 1931. Two hyperplastic



FIG. 8.



FIG. 9.

FIG. 8.—Mrs. S. F., fifty-five years old. Arthritic type. Kyphosis, backache, demineralization of spine, hyperostosis and calcified mesenteric glands. Calcium twelve milligrams, chronic, .41/1000. Note arthritic and hyperostotic processes in the kyphotic spine. Marked clinical improvement after operation.

FIG. 9.—E. B., six years old. Juvenile type. Pathological fractures at two and three years (femurs), again at five years. Bluish sclera, enamel defects, bowing of tibiae, widespread demineralization. Calcium twelve milligrams. Diagnosis fragilitas ossium, but all the earmarks of parathyroidism in all bones.

parathyroids were removed, microscopically, aside from extremely rich vascularization, not showing any outstanding pathology. Exactly six months after this date we had the first opportunity to examine this patient again. He hears 50 per cent. better, as he expresses it. He can walk three miles, whereas before the operation one hundred yards exhausted him. He has straightened up so that he has regained two inches of his lost height. This man is rather a pessimist, therefore his statements are of value. The head size by measurement is the same, sixty-six centimetres. He hears ordinary conversation very well, whereas before the operation we had to shout at him. A watch is heard by holding it close to the ear. The X-ray shows that the peculiar cotton-like (nigger wool) appearance of the outer table of the skull is disappearing and the normal structure of the skull returning. (Figs. 6 and 7.) His blood calcium is 8.6 milligrams per 100 cubic centimetres of serum.

Our advice, although guarded and reserved, would be to do a parathyroidectomy in a case of Paget's disease if recognized long before malignancy supervenes, especially if the case is accompanied by pain in the bones and hypotonia of muscles—symptoms similar to parathyroidism with osteitis fibrosa cystica, and if the X-ray suggests mixed findings of osteitis fibrosa cystica and osteitis deformans. These indications should not be disregarded in the absence of a marked elevation of serum calcium.

(3) *Arthritic Type*.—In our considerations so far, and in the statistics from the literature, the Oppel type of ankylosing polyarthritis for which parathyroidectomy is recommended, and on which, up to 1928, Oppel had reported seventy operations, has not received the attention that it should receive. It is not mentioned in the recent statistics (Helström). Our orthopaedic colleagues at Harper Hospital are convinced that parathyroidectomy has benefited some of their ankylosing polyarthritic cases, and they refer these patients quite liberally for consultation as to the advisability of parathyroidectomy and for operation.

This group is characterized by slight elevation of serum calcium, arthritic processes, spur formation around the vertebræ and other joints, kyphosis, moderate decalcification, some compression of vertebræ and lime metastases in anterior and lateral vertebral ligaments, abdominal lymph-glands, costal cartilages, and many internal organs (kidneys, liver, spleen, gastric mucosa, blood-vessels, *etc.*) and muscular hypotonia. Of this group we have had personal experience of thirteen cases with good results in six, two cases with no results, and two with partial results. In three cases the observation period has been too short to register reports. Proper selection of these cases will bring better results.

Besides the reports from Oppel's Clinic, Leriche, in his work on "The actual basis of parathyroidectomy in certain cases of ankylosing polyarthritis," Heineman and Gruda in their "Observations concerning the question of ankylosing spondylitis, and also, on the histological changes in the epithelial bodies and thyroid in ankylosing polyarthritis," Jung, of France, and Beresin, of Russia, have given favorable reports on Oppel's work.

Fig. 8 with its legend gives an example of our experience with this type.

(4) *Juvenile Type*.—We have operated upon three children and three adults where the disease started in infancy and was first regarded as osteochondroma, fragilitas ossium or osteogenesis imperfecta. We have found in this group that a good many had changes in the skeleton generally, especially in the skull, suggesting osteitis fibrosa cystica by its fine granular mottling; muscular hypotonia with frequent falls and serum calcium of at least the higher limits, and we have the impression that some of this group were caused by early or congenital parathyroidism. Our experience is not great enough for us to make positive statements, but striking enough to draw attention to the possibilities.

Shallow, of Philadelphia, has also published such a case and called it an arrested type of parathyroidism, arrested because the process seemingly stopped after one leg had become much shorter than the other on account of the osteitis fibrosa cystica affecting the epiphyseal lines and on account of the rest of the skeleton seemingly not being affected. But we think this type also stays more or less progressive and persevering in its symptoms. Even in the type with blue scleræ and osteochondritic changes usually considered forms of arrested embryological development, and therefore excluded from the endocrine types, it cannot be clearly stated whether or not fetal



FIG. 10.—E N, ten years old. Pathological fracture of left femur in 1926, extensive destruction of cancellous bone, two more fractures since, now left leg two inches shorter. In whole skeleton mild changes of osteitis fibrosa cystica (arrested type, Shallow), our own observation, improving after parathyroidectomy.

or early in life acquired parathyroidism is responsible. (Figs. 9 and 10.) For instance:

CASE IV.—Miss J. R. G., now thirty-five years old, was always small—dwarfed since childhood, with very fine intellectual development, had attacks of pain in the long bones, frequent falls, X-ray changes in the spine, decalcifications in the long bones, mushroom forms of femur heads. But now after thirty years she shows X-ray signs of osteitis fibrosa cystica, high calcium and low phosphorus readings, severe muscular hypotonia with frequent falls, and off and on she injures her bones—no doubt a clinical picture of parathyroidism.

PARATHYROIDISM

All these types of juvenile bone disturbances should be re-studied, especially the fragilitas ossium and achondroplasia, *etc.* A few of our figures will illustrate our own experiences.

(5) The *Myasthenic type* of parathyroidism deserves prominent attention. Hypotonia of the muscles is often such an outstanding symptom that some patients are grouped as myasthenia gravis, muscular atrophy, or spinal-cord tumors, *etc.* The skeletal symptoms may not be as prominent in this type as the hypotonia. For instance:

CASE V.—Miss M. F., nurse, aged forty-five years. Except in her twenty-fifth year when she had pulmonary tuberculosis which was absolutely arrested by sanatorium treatment, this patient enjoyed good health, worked every day and was very lively in her movements and actions. In 1926, she had her first attack of pain in the scapula and arms, which improved within a few weeks. She was diagnosed as "myositis" at that time. In November, 1931, she complained of backache which became so severe that she had to give up her nursing. She became weak, her lively gait became very much slower and she found it necessary to ride even short distances to get around. "Back and leg ache" was prominent, also the arm and hand movements became painful. The X-ray showed only a small area of cystic condition in the ilium just below the right sacro-iliac joint. There was some hypertrophic arthritis, not extensive however, around the vertebræ and the sacro-iliac joints. The usual orthopædic treatment, medical and dental care, *etc.*, gave no relief. The serum calcium during the observation ran from ten to thirteen milligrams. The serum phosphorus ranged from two and one-half to three milligrams. The chronaxie was lengthened to 0.3/1000 which is quite characteristic of hypotonia. The symptoms progressed so that she was confined to bed. The R-T interval was reported "just below normal and suggestive of hyperparathyroidism." Rest in bed gave no relief. The hypotonia, the clinical symptoms of muscular weakness, the chronaxie and electrocardiogram suggesting parathyroidism, parathyroidectomy was agreed upon and performed January 7, 1932. The specimen showed hyperplasia of the parathyroid body with new acinar tissue undergoing cystic change. The pain in the muscles and limbs for which morphine was required ceased immediately. Within six weeks she was herself again and returned to her work. The pain has not entirely disappeared, but is of a superficial type brought on by hand shaking, *etc.*, as is seen in many cases of parathyroidism. This patient was operated on rather early on account of the hypotonia, before severe bone changes were present. The results warrant the early operation.

CASE VI.—J. A. B., a woman, fifty-four years old, in charge of a large industrial first-aid station. At the age of thirty-three years she had early menopause brought about by surgery for pelvic inflammatory disease. She became very fleshy and in 1930 weighed 200 pounds. In spite of this fat she said that her muscles were so weak that "they quivered" (a symptom also mentioned by Rowntree). She fell several times without any stumbling—the legs "just gave away." There were also some gastrointestinal symptoms without any clinical findings in the X-ray, *etc.* The basal metabolic rate was plus twenty-five without appreciable goitre. Serum calcium went from eleven to thirteen milligrams. The urinary calcium output was twenty-three milligrams for twenty-four hours. X-ray of the skull showed some erosion of both inner and outer tables, especially in the occipital region, and some hyperostosis in the frontal region. Calcification of the pineal gland. This process in the skull was not diagnostically characteristic to our röntgenologist. There was a striking calcification of the nucleus pulposus between the first and second lumbar segments and calcium deposits over the anterior aspect of the lower dorsal segments. (Fig. 11.) From the hypotonia, frequent falling and X-ray changes, especially the metastatic calcium process, we made the diag-

nosis of arthritic type of parathyroidism with outstanding hypotonia. We did a parathyroidectomy September 19, 1931. The parathyroid tissue removed showed cystic changes. Two lower parathyroids were removed with a subtotal thyroidectomy. The result is striking as far as the hypotonia is concerned. She is back at her work and has not been subject to frequent falls as before the operation. She is still treated with calcium, but her blood calcium has returned to normal—8.8 to 9.2 milligrams since her operation.

Such cases have also been published by Frank and Allen and commented upon by L. C. Rowntree, by Compere, Hunter, *et al.* Frequent falls with-



FIG. 11.—Miss J. A. B., fifty-four years old, 200 pounds, in weight but extreme weakness of muscle, falls frequently, a few fractures, severe backache. Note calcification in intervertebral disc marked. Calcium twelve milligrams. Parathyroidectomy. No falls since, no pain or muscle weakness (eight months' observation).

out good reason and muscular weakness should suggest the possibility of parathyroidism.

We have made a good deal of progress in diagnosing this type of parathyroidism in that we have several methods of measuring the hypotonia of muscles accurately. Oppel mentioned, and uses frequently, the simple DuBois Reymond test, and states that it takes four milliamperes of current to cause contraction in the normal muscle, whereas it takes seven milliam-

PARATHYROIDISM

pères in a parathyroidism muscle. The muscle in tetany contracts with two milliamperes. This test seems to be fairly constant and is used a good deal in Europe as a symptom in tetany and parathyroidism.

Lapique originally introduced the conception of chronaxie as an electric time coefficient of neuromuscular excitability defined as a minimal time in which current must pass through a muscle or nerve in order to elicit a reaction. Fredericque and Bourguignon, from France, and David Wechsler, in this country, have written on this subject. To be brief, it takes normally 0.24/1000 of a second (0.00024 or 24 sigma) to get a reaction from the flexor pollicis; in tetany it takes only from 0.12/1000 to 0.14/1000 (0.00012 to 0.00014 of a second or 12 to 14 sigma); and in parathyroidism the time is lengthened to 0.48/1000 of a second. Bourguignon in his article claims that the lengthening of the chronaxie in parathyroidism is more reliable than

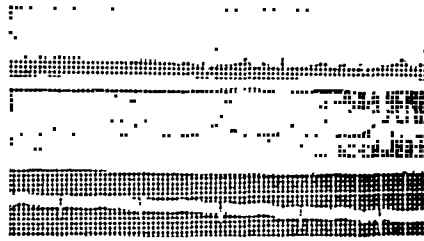
Parathyroidism					
Serum calcium & Chronaxie					
Age	Parathyroidism Type	Serum calcium		Chronaxie	
		Pre op.	Post op.	Pre op.	Post op.
61	Vertebral o.f.c.	11.6		0.19	
44	Pain & Hypotonia	10.5	11.0	0.30	0.27
40	Vert. o.f.c. ++	10.4	10.45	0.24	0.24
76	" "	12.9	9.48	0.33	0.16
74	Vert. & Hypotonia	9.5		0.32	
55	Vertebral	13.7		0.41	
48	"	12.0		0.40	
45	"	10.9		0.30	
62	Paget monostotic	12.7	10.97	0.36	0.23
63	Vert. & Hypotonia	10.0	11.4	0.15	0.16
10	Path. fractures o.f.c.	10.0		0.32	
50	Skull changes	13.3	9.48	0.33	0.16
26	Tetany	10.0		0.14	
26	"	6.-7		0.14	

FIG. 12.—Chronaxie tabulation.

the serum calcium, and that it returns to normal after parathyroidectomy more quickly than do the serum calcium and phosphorus. Generally this agrees with the observations Dr. Plinn Morse has made on our patients. A few exceptions, however, have occurred which may be errors in technic, or most likely due to some other reason interfering with this test. The method, however, deserves attention, and has become a great help in our diagnostic facilities for parathyroidism. (Fig. 12.)

Dr. E. D. Spalding, of Harper Hospital, has observed that the electrocardiogram will show changes in the excitability of the heart muscle similar to the changes in voluntary muscle. In tetany there is a delayed relaxation of the heart muscle, therefore the R-T interval, which normally lies between 0.26-0.28 second, is delayed to 0.30 to 0.34 and even as high as 0.39 second. After implanting some parathyroids in a case of tetany following thyroidec-tomy, this R-T interval returned to normal of 0.26-0.28 second. In para-thyroidism the opposite happens. In one outstanding case the R-T interval

went down to 0.22 second and rose again after parathyroidectomy to 0.27 second. (Figs. 13 to 16.) This electrocardiogram will perhaps become more



EKG on which original observation was made September 14, 1927.

Case M. McD.—Thyroidectomy with postoperative tetany.

R-T = .34" (Normal R-T = .26" to .28")

FIG. 13.—Electrocardiogram in tetany.

of a clinical method for measuring the muscular hypotonia than the somewhat difficult chronaximeter. (However, our chronaximeter built by Dr. Plinn F. Morse allows the test to be very easily taken.)

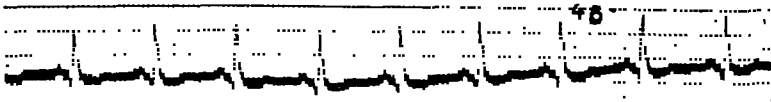


Case M. D.—After parathyroid transplant.

R-T = .24"

FIG. 14.—Electrocardiogram in tetany.

Doctor Rowntree has taken motion pictures of patients to illustrate the clinical manifestations of muscle weakness and also the vascular pulsations at times noticeable on account of the muscular weakness. He showed in



Case H. B.—Hyperparathyroidism with extensive bone changes.

R-T = .22"

FIG. 15.—Electrocardiogram in parathyroidism.

motion-pictures a patient, supine on the floor, who in attempting to rise had to roll over and climb up his legs in the manner of patients with pseudo-hypertrophic dystrophy.



Case H. B.—After parathyroidectomy.

R-T = .26"

(Dr. E. D. Spalding.)

FIG. 16.—Electrocardiogram in the same case after parathyroidectomy.

PARATHYROIDISM

We also have taken some motion-pictures, and the one I will present shows first, an interne walking with a normal gait; second an outspoken case of parathyroidism who can hardly walk the short distance from one chair to another, ten feet distant, slowly dragging her legs, and bent over; and third, the same patient four weeks after removal of a parathyroid tumor walking at a much livelier gait and with much better carriage.

Therefore, we have five means of determining the muscular hypotonia. First, the clinical symptoms of slow gait and frequent falls; second, the simple method of measuring by milliamperes the current needed to cause muscular contraction; third, the much finer and more dependable chronaxie



FIG. 17.

FIG. 17.—Mrs. C. L., forty-five years old. Typical scleroderma, sclerodactylia, etc. Calcium eleven milligrams. Phosphorus 2.2 milligrams. Note immobility of the wrinkled skin of the lips.

FIG. 18.

FIG. 18.—Same patient as Fig. 17 within two weeks after parathyroidectomy. Marked difference in appearance of lips.

determination; fourth, the R-T interval in the electrocardiogram; and fifth, the motion-pictures of the patients.

Besides the two cases mentioned, we have had in our experience many others who have had marked hypotonia of muscles along with other symptoms.

The five groups are not entirely separable from each other as already suggested by all symptoms being more or less present in each one, but characterized by one symptom being outstanding.

One of the rarer symptoms of parathyroidism for which parathyroidec-

omy has been recommended is scleroderma. Leriche has reported six parathyroidectomies and ligatures of the parathyroid artery for treatment of this condition apparently with success. I operated upon an outspoken case of scleroderma two months ago. The results so far seem to confirm Leriche's observations, but I reserve a final report of this condition for a later date. (Figs. 17 and 18.)

Treatment.—The general impression prevails that medical treatment—the administration of calcium salts, the support of absorption by giving vitamins in irradiated cod-liver oils, ultra-violet rays, *etc.*, should be tried. Some forms are initial and perhaps transitory. In our own experience we have had patients after faulty diet or having acquired osteomalacic conditions in puerperium, seemingly affected with parathyroidism, who have improved at least temporarily under such care. But an outspoken case with cardinal symptoms more or less present (not all are necessary) or with recurrence of symptoms after a temporary remission, should be operated upon.

Experience has now brought out very forcibly that it is not always large adenomatous tumefactions of the parathyroids that cause the disturbance. A parathyroid of normal size, without any recognizable gross change, can cause hyperfunction. Richardson, Vaughan, and we have had cases where the removal of seemingly normal parathyroids stopped severe processes of osteitis fibrosa cystica. Our co-worker, Dr. Plinn F. Morse, writes:

There seem to be two general types of hypertrophy, the compact type in which the cells merely proliferate in the form of a compact, uniform mass within the capsule, the whole gland appearing as a dense and uniform structure composed of chief cells with occasional acidophilic elements scattered through it, the whole being inclosed in a uniform fibrous capsule. This type of hypertrophy is particularly common in younger individuals and in individuals in whom the parathyroid apparently has hypertrophied compensatorily in response to a physiological need, such as osteomalacia, rickets and renal rickets. On the other hand, in the cases which we prefer to call primary parathyroidism at this time, which occur in older individuals and express themselves clinically as osteitis fibrosa cystica or Paget's disease, we find a type of hypertrophy consisting apparently of increase in peripheral lobules, so that the gland spreads out and becomes more diffuse with new forming lobular collections of cells at the periphery, with considerable amount of fat tissue between them. This loosely arranged structure of the parathyroid, in the normal individual, is more characteristic as age goes on and the senile gland in general is much more loosely arranged with a great deal more fat between the lobules than is the case in the glands of younger individuals.

The analysis of the cases so far published as well as a perusal of the microscopical findings in our own cases will make it evident that the question of parathyroidism is not one of microscopical structure of the gland. In the early part of this work all operators expected to find a parathyroid tumor. It became immediately evident that the tumor, in the sense of a neoplastic growth of the parathyroid, was practically never present. Various degrees of enlargement of adenomatous character, sometimes quite marked, were common findings in the outstanding forms of osteitis fibrosa; but many cases with outstanding bone changes and disturbances of calcium metabolism showed no gross enlargement, or at least very doubtful gross enlargement of the gland. However, the brilliant clinical results obtained by removal of one or more of these bodies seem to justify that the dyscrasia is a functional one, having to do with functional over-

PARATHYROIDISM

activity or possibly a glandular imbalance which is corrected by removal of some of the parathyroid tissue, and as a final consideration it must be borne in mind that there is no strict parallelism between the microscopical findings in the parathyroid and the clinical results which follow removal in cases in which the characteristic clinical, röntgenological and chemical findings make a diagnosis of parathyroidism justified.

Up to now fatal tetany has been reported four times, in three cases immediately after operation (Beck, Wanke, Ask-Upmark), and the fourth a more chronic type (Eggers) seven months after operation. This case was reported as suffocation from a fibroma of the vocal cord found at autopsy, but had all the ear-marks of tetany. In all four cases the surgeon looked

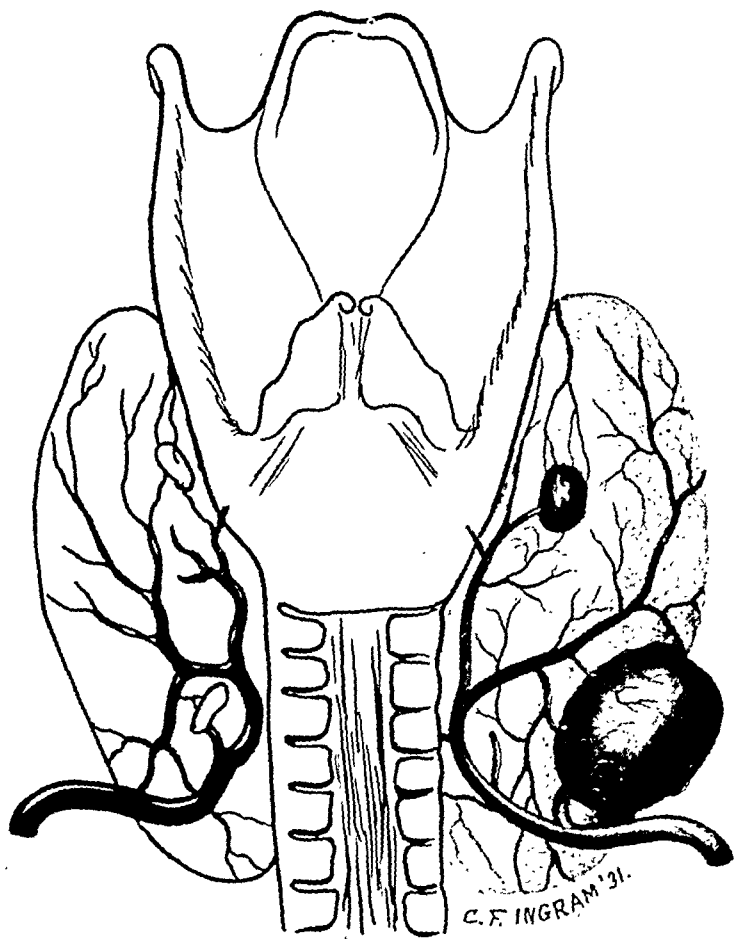


FIG. 19.—Mrs. H. C., sixty-three years old. Large parathyroid adenoma in well-marked classical vertebral type of parathyroidism shows the importance of surveying both parathyroid regions first, before starting to remove parathyroids. If the two on the left side were uncovered and removed first, the large tumor would have to be removed also and tetany would probably be the sequela.

first on one side and took out what he found—one or two parathyroids; then looking on the other side, he found a large adenomatous gland, so that three parathyroid bodies were removed. For this reason, we strictly advise, before removing any parathyroid tissue, a survey of both parathyroidal regions. (Fig. 19.) By means of a towel clip, first the left, then the right thyroid lobe (or vice versa) can be turned over mesially, and we can see at least if there is any gross tumefaction of the parathyroids present on either side before we start the parathyroidectomies. In one of Helström's cases, one

large adenoma was removed from one side. The patient improved only temporarily. The calcium stayed high. The symptoms returned in a few weeks and a second parathyroid adenoma was found on the other side at a second operation. It seems to be safer to do the operation in cases of several large parathyroids in two sittings than in one, so that gradual accommodation takes place instead of sudden tetany. Compare the two-stage lobectomy in cases of severe thyroidism. Routine biopsy by frozen section of all material removed will protect the surgeon from disappointment such as we had early in our work a few times, getting a report later than the tissue removed did not contain parathyroid elements. In all our parathyroidectomies post-operative administration of parathormone and intravenous calcium is given until the serum calcium level is constantly normal, generally for about one week, so that even suggestive symptoms of tetany have been entirely avoided.

BIBLIOGRAPHY

- Ballin, Max, and Morse, Plinn F.: Parathyroidism and Parathyroidectomy. From the Transactions of the American Surgical Society, *ANNALS OF SURGERY*, October, 1931.
- Brines, O. A.: Analysis of 1,535 Autopsies. *Amer. Jour. Clin. Path.*, vol. ii, p. 54, 1932.
- Hartman, Frank: Meeting of the Wayne County Medical Society.
- Helström, John: (Stockholm) Hyperparathyroidism and Osteitis Fibrosa Cystica Generalisata. *Acta Chirurgica Scandinavica*, vol. lxi, Fasc. II-III, p. 237.
- Shouten, D. E.: *Ned. Tydschr v. Genesk*, p. 75.
- Bourguignon, G., and Sainton, P.: Study of a Case of Osteitis Fibrosa Cystica with Paget's deformities. *Comptes Rendus*, vol. cvii, p. 51, 1931.
- Ballin, Max, and Morse, Plinn F.: Parathyroidism. *Amer. Jour. of Surg.*, vol. xii, new series, No. 3, pp. 403-416, June, 1931.
- Ballin, Max: Technique of Parathyroidectomy. *Surg., Gynec. and Obst.*, vol. liv, No. 5, p. 806, May, 1932.
- Joseph, Benjamin F.: *Amer. Jour. Dis. of Child.*, vol. xl, p. 81, 1930.
- Fromme, A.: *Arch. f. Klin. Chir.*, vol. 152, p. 601, 1928.
- Oppel, W.: *Zent. f. Chir.*, vol. xxxvi, p. 1916, 1931.
- Leriche: *Gaz. d. hop.*, vol. civ, pp. 729-731.
- Leriche, and Jung, A.: Paris Letter. *Jour. Amer. Med. Assn.*, July, 1931.
- Beresin, I. J.: *Ortop. i. travmatol.*, vol. v, No. 1, p. 66, 1931.
- Shallow, T. H.: Osteitis Fibrosa Cystica. *Surg. Clin. N. Amer.*, vol. ii, pp. 1327-1344, December, 1931.
- Heineman-Gruda: Observation Concerning the Question of Ankylosing Spondylitis. *Arch. klin. Chir.*, vol. cxlv, p. 145, 1927.
- Heineman-Gruda: Histological Changes in the Epithelial Bodies and Thyroids in Ankylosing Polyarthritis. *Virch. Arch.*, 269.
- Wechsler, David: Measurement of Chronaxie. *Med. Times, N. Y.*, March, 1930.
- Sainton, Hotel Dieu, Service d'electro-radiotherapie de la salpetiere et service de medicine. (See Bourguignon and Sainton.)

DOCTOR PHEMISTER (Chicago) thought Doctor Ballin's studies to be a real contribution to the subject of obscure skeletal lesions. On the other hand one must be guarded about trying to explain all of them on the basis of parathyroid disease. In the past four years he had determined the calcium and phosphorus content of the blood in seven cases of solitary bone cyst, three cases of regional osteitis fibrosa and ten cases of Paget's disease. In none of them had there been elevated blood calcium or lowered blood phosphorus. The solitary bone cysts are all easily cured by local operation, which speaks strongly against their being of parathyroid origin.

PARATHYROIDISM

DOCTOR BALLIN rejoined that bone cysts are a subject of great controversy. They may not all belong to the entity, parathyroidism, but the results of parathyroidectomy on these cysts at least give some suggestion that many of them are of parathyroid origin. For instance, Barr and Bulger, also Donald Hunter, have published several cases of multiple cysts in the jaws. Some of them were scraped out and healed, but some returned. After parathyroidectomy all the cysts healed, without being touched.

About the high calcium: he had gone through a similar period in his thyroid experiences. For some time he hardly ever operated on goitres unless they had high basal metabolic rates; the same here, if most of the clinical symptoms of parathyroidism are present, high calcium is not always necessary; in fact, the French have published an article lately where they look much more to the hypotonia of the muscles for guidance than to the calcium finding. Muscle hypotonia may be measured by chronaxie and by electrocardiogram. Chronaxies are the mathematical expression of the time factor intervening between the least stimulus and the contraction of a certain muscle. The normal chronaxie for the flexor digiti quinti is $.28/1000$ of a second. In parathyroidism this figure goes up to $.40/1000$ and $.50/1000$ of a second; in tetany, on the other hand, it goes down to $.18/1000$ of a second. (Dr. Plinn F. Morse.)

This muscle weakness also shows itself in the electrocardiogram. The R-T interval is shortened in parathyroidism and lengthened in tetany. (Dr. Edward D. Spalding.)

He had many observations now showing these two tests to be reliable. If he operated on cases of parathyroidism only if they have fifteen and twenty and more milligrams of calcium per 100 cubic centimetres of serum, he was sure they would miss a good many cases that could be helped. The serum calcium is not high all the time; there are intermissions and other factors disturbing this test.

ANEURISM OF THE INNOMINATE ARTERY

BY ARNOLD SCHWYZER, M.D.

OF ST. PAUL, MINN.

IN REGARD to the treatment of aneurism of the innominate artery considerable pessimism is encountered in the literature. Up to 1902, Jacobsthal had found among 120 cases of combined aortic and innominate aneurisms reported by him as treated by distal ligation, only two living more than three years after operation. Last year, LaRoque, in a paper in the April number of the *ANNALS OF SURGERY*, declared: "Aneurism of the innominate artery has never been removed. The vessel has been ligated several times, and in the few that survived the operation, some benefit but no cure has been attributed to it." This statement is, however, not quite correct. Imai, a Japanese, published a case of excision of a small hen's-egg-sized aneurism, which at the time of writing, four and a half years after the operation, was in good condition. (*Deutsche med. Wochenschr.*, 1913.) Rosenstein, of San Francisco (*Osler, Modern Med.*, 1927), operated upon a perforating case. The patient is said to have lived many years after. Da Costa made a distal ligation of carotid and subclavian arteries in two cases, one of which appeared cured five years later, after which he was lost track of. Guinard, of the Hotel-Dieu Hospital of Paris, wrote in a rather optimistic spirit on the subject of distal ligation in the *Revue de Chirurgie*, February 10, 1909.

Without going further into the literature of the subject, I will simply report a case which to my knowledge represents an unusually long observed operative result. F. J. R., of Havre, Montana, came under my care on November 7, 1909. His history was in short the following: He had acquired lues in the spring of 1903. The medical treatment was very short and entirely inadequate. He felt, however, well until in April, 1909, he noticed a small pulsating bulb above the right clavicle. Gradually this pulsation became more marked. With the appearance of the protrusion (Fig. 1) some pain came on in the right shoulder and on the inner side of the right arm. He did not see a physician until June 1. By that time the pulsation was strong. He was immediately put to bed, and after a few days sent on a stretcher to St. Paul. Here he was kept flat on his back under the charge of a prominent internist. A surgeon was consulted, and he advised against operative interference on account of the threatening appearance of the pulsating mass. Mercury inunctions, K.I. and calcium lactate were given. When seen on November 7, patient had been flat on his back for over five months, and during the last six weeks had not been allowed to raise his head even while eating.

The examination of the otherwise healthy man of thirty-one years showed a strongly pulsating tumor on the right side of the neck, reaching from the mid-line in the jugular fossa to the posterior edge of the *scaleni* region. With its upper conical, though rounded outline, it reached to a level with the upper portion of the thyroid cartilage. The lower edge of the bulging extended down over the anterior surface of the clavicle. The transverse diameter of the mass from the jugular fossa toward the right and back measured six and one-half centimetres. The point of greatest bulging was one and one-half centimetres above the clavicle just laterally to its head. In the jugulum extensive pulsation was felt as far as the finger could enter on deep pressure. Pulsation in the carotid cephalad from the aneurism seemed to be weaker than on the left side. In the

first and second interspace below the right clavicle there was some dullness, but no pulsation was made out. This finding is of interest because a radiogram which the patient sent me two months ago (March, 1932) shows a normal condition of the aorta. This radiogram makes it definite *a posteriori* that we were dealing with an aneurism which was localized to the innominate artery, and not involving the aorta. All the heart sounds were normal. Both radial pulses were synchronous, while as to the temporal arteries we were in doubt. They were then examined in the following way: After both pulses are first well established under the fingers, then the examiner, seated behind the patient, closes his eyes and remains in the same position for some time until he is not conscious of the position of the hands. He can now imagine that he feels the same blood vessel at different levels. While before it had been uncertain which side was beating first, it now appears plain that the blood in the supposedly single vessel runs from under the left hand to the right one; in other words: the pulse in the right temporal was a little retarded. Digital compression of the carotid was then done repeatedly up to three minutes at a time, in order to give us assurance

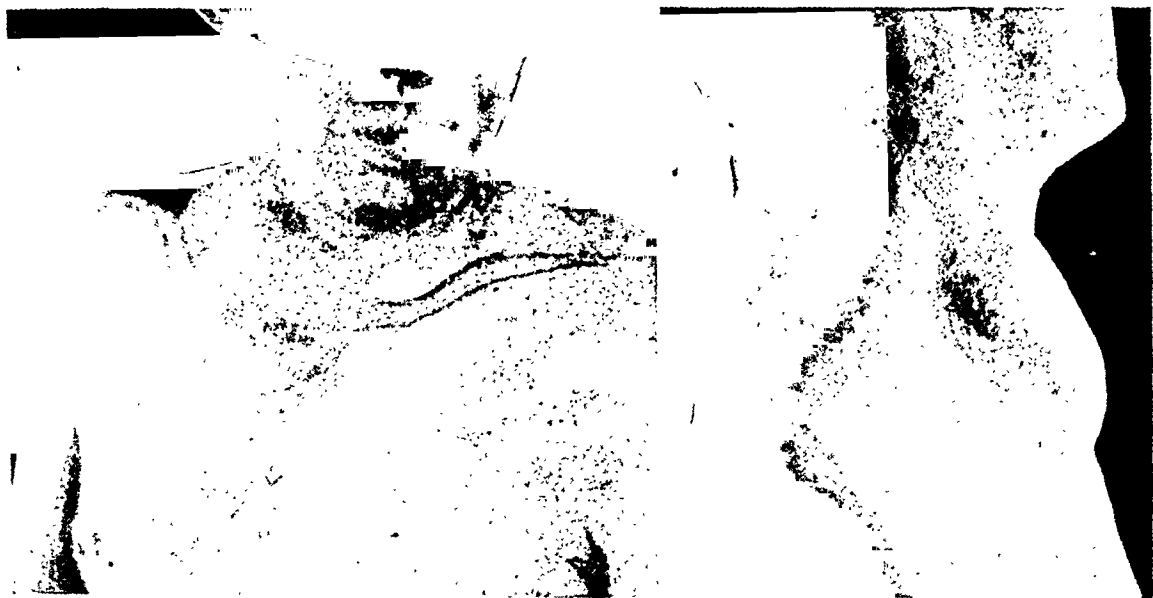


FIG. 1.—Aneurism of the innominate artery, November, 1909. Anterior and lateral views.

that ligation would not cause dangerous cerebral symptoms. The pulse ranged between 72 and 96; the temperature was normal.

November 23, 1909, the operation took place at St. Joseph's Hospital. Before the ether narcosis was started, both legs were tied off near the groin in order to sequestrate a large amount of blood by passive hyperæmia. Thus we thought to reduce the blood-pressure and secure a reserve supply of blood for an emergency. An incision was made in the skin-fold over the sternomastoid muscle near the upper border of the mass. The common carotid was freed directly behind the upper pole of the aneurism and ligated with No. 3 formalized catgut after we had assured ourselves that the arterial walls felt normal. The skin was closed and a second incision was now made above the outer portion of the clavicle and parallel to it. The brachial plexus had to be pushed outward and backward and the aneurismatic sac inward, after which the third portion of the subclavian artery was reached. Guinard's statement that these aneurismatic sacs after freeing can often be dislodged and compressed quite freely proved to be very correct in our case. After ascertaining again that the artery was normal in size and flexibility, it was ligated with No. 3 formalized catgut and the skin closed. The pulsation in the aneurism had not changed by the time the dressing was put on. Pulse and respiration had remained unaffected during the operation. Tonometer readings* had been made on each arm previous to the operation before and after sequestrating

* Tonometer readings were done in those days by taking the lowest pressure at which the radial pulse disappeared.

the blood into the legs. The sequestration had made no difference in the readings. On the right arm the systolic pressure had been 100 millimetres mercury, and on the left 112. After the operation the blood-pressure in the left arm was 110; on the right wrist no pulsation could be felt. The pulse rate at the end of the operation was 90. The right arm was wrapped in cotton. For four hours the arm remained cold, but after that it warmed up. Eleven hours after the operation the hand was quite warm and there was no trace of pain in the arm. Good motion and sensation. On the following morning there was some faint pulsation at the right wrist. Forty-eight hours after the operation the patient was allowed out of bed. On the following day the dressings were changed for inspection. Even on close examination there was now only a vague impulse to be seen apparently transmitted by the rigid thrombosed sac. On the tenth post-operative day our patient left the hospital.

Three years later he married. In December, 1914, he had a bad runaway and was dragged for some distance. His right wrist was broken, and he received many bruises, but the aneurism did not seem to make any trouble. Upon my inquiry he wrote in



FIG 2—Photograph taken in October, 1931, twenty-two years after operation.

October, 1931, that he felt splendidly (Fig. 2); that he had continued general ranch work, including the breaking of bronchos, until 1923—in other words, for nearly fourteen years after the operation. He further stated: "It was financial trouble and not physical disability that made me quit the ranch life."

In regard to the operative procedure it is much the best to ligate both arteries at the same session. The walls of the arteries should not be calcified nor even markedly atheromatous at the place of ligation, as otherwise it may occur that a secondary aneurism develops at the site of ligation, like, for instance, in Da Costa's second case. Guinard emphasized as of greatest importance that the carotid be taken care of first, because otherwise, as it happened to Riche (Guinard, *l.c.*), due to the suddenly changed whirls in the aneurismatic sac, loosely attached parietal thrombi might be thrown into the cerebral vessels. Due to the free communication between the right and

left external carotids a reversed flow of blood occurs in the external carotid of the ligated side which then supplies the corresponding internal carotid. This renders ligation of the common carotid much safer than that of the internal. Terrier observed while ligating the common carotid that the temporal artery kept right on pulsating as before. It is claimed that ligation of the common carotid causes intracranial complications in from 20 to 25 per cent. of the cases and that half of these die. The Swiss ophthalmologist Siegrist, gathered 997 cases of ligature of the common carotid (v. Graefe's Archiv fuer Ophthalmologie, 1900) and came to the conclusion that the danger of ligating one of the common carotids is really very slight if severe atheromatous changes and wound infection with consequent ascending thrombosis or secondary hæmorrhage are excluded. The remaining deaths were mostly *not* due to the ligation itself, but to pre-existing causes like a serious heart lesion or a greatly debilitated condition in malignant disease or after severe pre-operative hæmorrhage. However, some of the deaths were due to faulty operating causing injury of the vagus nerve. Impressed by this study, Guinard made an examination of the fatalities of ligature of the common carotid in his own cases and those of the other members of the Paris surgical society, and showed them due either to obliteration of the carotid of the other side or to a serious damage to the intercommunication between the two external carotids, as after operation for malignancy of the maxillary area. Excepting these two contingencies he declared flatly that the mortality in ligation of the common carotid is "absolument nulle."*

Babcock emphasizes the increase of the intra-aneurismal pressure when distal ligation is made. At the moment of ligation this is of course true, but physiological study of the function of the cardiac depressor nerve indicates that the blood-pressure in the aorta is well adjusted to the requirements of the blood supply to the vital organs. Furthermore, our case shows that the sac was very soon thrombosed enough to transmit only a vague impulse and that expansion had ceased. It might be of help to use some kind of support or compression for that length of time in case perforation is imminent. Babcock's procedure of carotido-jugular anastomosis appears to be very valuable for aneurisms of the thoracic aorta; but when performed for aneurism of the innominate artery, it renounces from the start the attempt to obliterate and thus completely cure the aneurism.

The result in our case has now lasted twenty-two and one-half years, and it would be hard to pick out severer tests after operation for a large innominate aneurism than run-aways and broncho-busting. However, we were favored by two factors of importance, first and before all the limitation of the aneurism to the truncus anonymus leaving the aorta uninvolved, and second the healthy condition of the arteries at the site of ligation.

* I have ligated the common carotid several times without untoward symptoms. In two cases it was for aneurism of the internal carotid. One of these was an aneurism in the cavernous sinus with exophthalmus pulsans. The patient, a woman, was reported to be well eleven years later. The other, also a woman, had her aneurism directly above the sella turcica. She was operated upon four years ago and is well today (published in Minnesota Medicine, August, 1930).

SUBCLAVIAN ANEURISM

BY ELLSWORTH ELIOT, JR., M.D.

OF NEW YORK, N. Y.

THE subject of subclavian aneurism is most conveniently divided, as is aneurism in general, into those of the spontaneous and those of the traumatic varieties.

From a long period, extending over several centuries, the clinical features and the pathology of the spontaneous variety and to a certain extent its surgical treatment as well, have been thoroughly standardized. On the other hand, in aneurism following penetrating wounds or other forms of trauma, the symptoms and treatment are still in such a formative stage that further study and discussion are required.

The treatment of spontaneous subclavian aneurism was presented by the writer in a paper read before this Association in 1912. Proximal ligation was then, and still is the operation of choice which, if unsuccessful, may subsequently be supplemented by distal ligation with or without excision of the sac. In aneurisms of the first portion of the vessel, ligation of the innominate must be done. In aneurisms of the second or third portion the ligation of the first part of the artery may be supplemented by ligation of the internal mammary and thyroid axis. If the artery proximal to the aneurism is atheromatous, distal ligation as close as possible to the aneurismal sac is justifiable. Pearson, in a case of this kind, permanently cured an aneurism of considerable size by distal ligation after an attempt to ligate the first part of the artery disclosed an extensively sclerotic condition in which the artery was adherent to its sheath, and to the cervical plexus.

The exposure of the innominate or of the first part of the subclavian is facilitated by the resection of the inner end of the clavicle with or without the adjacent part of the manubrium of the sternum. In the ligation of the deeper part of the left subclavian a satisfactory exposure of the vessel can be secured through the posterior mediastinum.

All kinds of absorbable and non-absorbable material including chromic gut, silk, kangaroo tendon, linen bands, fascial strips, together with special clamps such as those devised by Halsted, have been used in different varieties of ligation with equal success. Successful ligation of the abdominal aorta is still relatively an unsolved problem. The form of knot has also varied, the double ligature being favored. The patient of Hamann, who used braided silk, and of Vaughn, who used tape, survived the operation and lived for six months and two years respectively. At present fascial strips, especially in the ligature of large vessels are generally preferred. Campbell, who has used this material in the ligation of the common carotid in three instances and of the popliteal in one, states that "simple ligation and treat-

ment by other methods has not given nearly such good results in my hands or in the hands of my colleagues."

The paper above referred to gave the clinical history of a patient suffering from a spontaneous aneurism of the third part of the right subclavian artery, in which a cure was effected by a ligation of the first part of that vessel. The ligation of the main artery was supplemented by separate ligation of all its branches with the exception of the vertebral, in order that a clot of sufficient length and strength might diminish the possibility of secondary hæmorrhage when the lumen of the vessel was opened by the cutting through of the ligature. At the end of five years no recurrence had developed and during the last four years of that period no precaution had been taken in restricting the use of the right arm. A Wassermann reaction, however, still gave a four plus positive reaction. At the end of twelve years the patient's condition was unchanged.

I am indebted to my former resident, Dr. Ralph Colp, of New York, for permission to add the end-result in the case of a patient presented to the New York Surgical Society, in which a subclavian aneurism on the right side was treated by a similar operation. Doctor Colp informs me that the aneurism had shrunk to the size of a tennis ball and that it was of firm consistency at the end of two years when the patient suddenly died from the effects of an apoplectic seizure.

The ligation of the branches of the subclavian artery in these two cases necessarily eliminates channels through which a considerable part of the collateral circulation would ordinarily be established. The fact that in both patients the radial pulse returned (in the writer's case, on the fourth post-operative day; in Doctor Colp's case, somewhat later) and that no œdema or circulatory disturbance persisted, indicates that the anastomosis between the thoracic intercostals and the thoracic branches of the axillary was sufficient to provide an adequate collateral circulation. Hertzler reports a case in which three weeks after the successful ligation of the innominate for subclavian aneurism the vertebra and common carotid arteries were ligated for a recurrent pulsation without ill effect. Guleke also reports a case in which the ligation of the subclavian was supplemented by the simultaneous ligation of its branches without subsequent circulatory interference.

While this measure does not seem to impair the establishment of adequate collateral circulation, it does not always avert the danger of secondary hæmorrhage. In the case of an identical operation to control the hæmorrhage due to extensive wounds from a shell fragment in the right supraclavicular and axillary regions, which occurred during the Argonne campaign, secondary hæmorrhage developed during the third week following the operation from the penetration of the lumen of the main vessel at the point of ligature from the effects of which and from the intense infection the patient died. The presence of infection markedly predisposes to the occurrence of this unfortunate complication irrespective of the type of operation employed.

whether ligation, the reconstruction of the arterial continuity by suture or the endo-aneurismorrhaphy of Maras.

Another greatly-to-be-feared sequela of operation for aneurism is gangrene of the extremity. While this may be due in part to lack of an adequate number of anastomotic channels, the presence of infection undoubtedly plays a much more important rôle. In pre-antiseptic days the simplest ligation was necessarily subject to infection. The thrombosis in small blood-vessels divided in the exposure of the main arterial trunk might spread to such an extent as to permanently occlude many vascular channels on the patency of which the establishment of adequate collateral circulation depended. Although in the aseptic operation of today such an unfortunate diffuse thrombosis is avoided, the bug-bear of gangrene, especially in war surgery in which infection is such a common complication, persists.

It is generally agreed that gangrene is more common after operations for traumatic aneurism than after those for the spontaneous variety. In the latter the possibility of post-operative infection can usually be eliminated. Furthermore, because of the interference of the normal flow of blood through the aneurismal sac, the establishment of a partial collateral circulation has usually taken place. While in this group the presence of atheroma, if diffuse, favors the development of gangrene, the general weakness from the loss of blood and the consequent diminished blood supply of the affected extremity are factors of considerable importance in the traumatic variety. Moreover, in this same variety the damage to the main artery is not infrequently associated with simultaneous division and consequent occlusion of many of its collateral branches. In this connection the statistics collected by Wolff are of the greatest interest for they include the consideration of several hundred cases of gangrene both prior and subsequent to the aseptic era. They show that, in the latter period, gangrene occurred in 4.8 per cent. of the cases of ligation of the subclavian artery and even with much greater frequency after the ligation of other large vessels, the popliteal as in pre-antiseptic times, still showing a relatively high percentage. Lexer, referring to these statistics, states that, in his experience, gangrene is even more frequent than the tabulation of Wolff would indicate, although no specific details are given. On the other hand, in Halstead's statistics based upon 142 cases in which all the various types of operation were done under antiseptic precaution, gangrene occurred in three instances, namely, after a ligation, after an excision and after an endo-aneurismorrhaphy of the popliteal artery. The testimony of Von Haberer is also of great interest, namely, that in seventy-two cases of wounds of arteries observed during the war only in one did gangrene develop. Bier also states that in fourteen ligations for traumatic aneurism during the war, no instance of gangrene or, in fact, of any circulatory disturbance was noticed. This he largely ascribes to the careful conservation of the branches of the damaged vessel.

While cases collected from the records of a single clinic or from the experience of a single observer are obviously more reliable than a general

compilation gathered from the literature, it must be emphasized that even though no gangrene develop, the interference with the blood current resulting from operations for aneurism, especially for the traumatic variety, not infrequently is followed by pain, muscular contractures, paralysis, atrophies and symptoms of impaired circulation. In Halstead's statistics a case of paralysis is cited after a Matas operation for popliteal aneurism. Wolff also states that of thirteen cases examined by Frish only five were free from some one of these sequelæ. After ligation of the subclavian the radial pulse cannot usually be felt for several days. It then becomes palpable, gaining in force for several weeks, although some permanent weakness persists. In this connection Stewart, from two observations of the flow of blood after ligation of the innominate for subclavian aneurism, states that at the end of a month approximately three-fifths of the normal blood current in the radial artery were restored. Von Haberer emphasizes that the restoration of the circulation is more complete after arterial suture than after ligation and usually enables the individual, if a soldier, to resume full military duties.

To eliminate the possibility of gangrene Matas devised the operation of endo-aneurismorrhaphy and Lexer, with other German surgeons, developed the restoration of arterial continuity by suture, anastomosis or by the filling of the gap between divided arterial ends with a segment of the internal saphenous vein.

While aseptic surgery has not eliminated the danger of secondary hæmorrhage or of gangrene it has at least extended to a great degree the field of successful surgical therapy. To it must be ascribed the comparative freedom from risk involved in the excision of an aneurismal sac after distal and proximal ligation of the afferent and efferent vessel. It has also made possible the brilliant operation of aneurismorrhaphy advocated and introduced by Matas. While in aneurism of the subclavian, iliacs, or other large arterial trunks some form of ligation is considered preferable by many surgeons, it is the general consensus that the Matas operation is especially applicable to those aneurisms of the extremities in which the establishment of adequate collateral circulation is doubtful. Yet even this ingenious operation is not free from the risk of gangrene. In 1912 the writer called attention to the fact that this complication had occurred in cases that were never reported. The master hand of a Matas cannot easily be duplicated, even by skillful surgeons in whose experience this operation is relatively uncommon.

Aseptic surgery, in combination with intratracheal anæsthesia, has also made possible the operative relief of intra-thoracic aneurisms of the left subclavian and common carotid arteries in which a healthy segment intervenes between its origin from the arch and the site of the aneurism. In this group the aneurism is exposed, after an X-ray examination, through either the anterior or posterior mediastinum. If the subclavian is involved, the more superficial common carotid, if the anterior route is selected, is a valuable guide especially when an overlying aneurism makes the identification of the former vessel difficult.

The consideration of certain clinical features and of the pathology of traumatic aneurism, especially of the subclavian artery, may advantageously precede a discussion of their surgical therapy. The appearance of aneurisms of this type usually promptly follows the trauma. Exceptionally weeks or months may intervene between the receipt of the injury and the development of unquestioned aneurismal symptoms. In the former group surgical therapy may be immediate or delayed. In the latter group radical measures are impossible until the diagnosis of aneurism is established. In the subclavian artery as well as in the traumatic aneurism of other large accessible vessels the gradual appearance of a swelling having expansile pulsation is essential to diagnosis. The presence of a soft blowing murmur with or without a thrill is a reliable symptom only when the detection of expansile pulsation is concealed by the depth of the aneurism beneath overlying structures. Jastrum refers to a patient in whose case a marked thrill with a constant murmur, intensified in systole, developed five months after a perforating bullet wound above the right clavicle without a pulsating tumor. The compression of the subclavian trunk on the proximal side obliterated both the thrill and murmur as well as the radial pulse. Exposure of the supposed aneurism revealed normal subclavian vessels. The thrill and murmur, following the operation, disappeared but gradually recurred and in three weeks had reached their former intensity. These unusual physical signs were ascribed to the narrowing of the vessel by scar contraction. Jastrum refers to twelve similar cases observed by other surgeons with no mention of clinical details.

Cotte also reports a case of absence of the radial pulse after a bullet wound above the clavicle for which, four days afterward, in the absence of a tumor, an exploration was undertaken. No aneurism was found. The wound promptly healed. Ten days later an aneurismal swelling appeared with disturbances in the distribution of the seventh and eighth cervical nerves. The writer recalls the discovery of a soft blowing murmur in the course of the physical examination of the chest of a young man over the mid-clavicular region. There had been no history of trauma and the murmur had been discovered in the course of an examination for an insurance policy. It was ascribed to the narrowing of the lumen of the subclavian artery by pleuritic adhesions over the apex of the lung. The diagnosis could not be substantiated by the X-ray which at that time had not been discovered. No aneurism ever developed and the patient is still alive and well.

The persistence of a murmur after the excision of an aneurism has been observed by various surgeons, including Heinlein. One instance of this kind was observed by the writer after the excision of an arteriovenous aneurism of the temporal artery in the parotid region.

The surgical treatment of aneurism, especially of the traumatic variety, presents several interesting problems. Cases in which the collateral circulation is unquestionably adequate are best treated by the excision of the sac, preceded by ligation of the afferent and efferent vessels. Such an operation is always indicated in aneurisms of the scalp and in the distal por-

tions of the extremities. A similar operation may also be done for aneurisms of some of the larger vessels including the subclavian, although it is contraindicated when uncontrollable hæmorrhage is likely to occur in the course of the excision of the sac.

In the treatment of aneurisms following penetrating wounds conservative and radical measures have their advocates. The subsidence if not the complete disappearance of aneurisms of small size, even of the larger vessels, through rest, diet, and medical therapy has been noted. The spontaneous cure of traumatic aneurism has also been proved in wounds of the brachial, axillary, subclavian and common carotid arteries by various surgeons in operations performed weeks or months subsequent to the trauma for associated injuries of important nerves. Lehman reports a case in which an aneurism of the eighth subclavian and innominate (the latter verified by X-ray) was due to the penetration of the fragment of a shell in 1917. No operation was done (possibly on account of the location and extent of the aneurism). Almost three years later marked improvement was noted, being indicated by a diminution in the intensity of the physical signs and by a greatly decreased area of dullness. For the past three years patient has been working as a draughtsman (1924).

Kirchner reports a case of a small aneurism of the left subclavian above the left clavicle due to a bullet wound through the left shoulder. This, after remaining stationary for ten years, suddenly increased in size subsequent to some unusual exertion requiring ligation of the left subclavian with imbrication of the sac.

Spontaneous cure in these aneurisms is favored by a complete division of the artery which permits the retraction of the divided ends. A persistence of the aneurism is more likely to follow a perforation of the arterial trunk.

Reidel emphasizes the value of the treatment of traumatic aneurism by the local pressure of rubber sponges with overlying sand-bags, supplemented by proximal digital pressure of at first fifteen minutes' duration, gradually increased to an hour. Twelve cases were treated in this way including an aneurism of the left subclavian, the size of a fist, which was cured. A cure also was obtained in aneurisms respectively of the left carotid, the external iliac and the superficial femoral. This method of treatment is contra-indicated if rupture is threatened, or if incipient infection develops. Riedel emphasizes the fact that traumatic aneurism in which the wall of the artery is healthy is more frequently benefited by this measure than a spontaneous aneurism in which atheroma of the involved artery is frequently present. He further states that the danger of rupture diminishes as the aneurism decreases in size and that the complication of embolus from the effect of pressure is not great.

Conservative measures are not without their drawbacks. The gradual formation of the aneurismal sac which, according to Von Haberer, is sufficiently advanced by the seventeenth day to permit its excision, becomes usually so incorporated with the adjacent brachial plexus that a separation

of the nerves is difficult. Moreover, the gradually increasing pressure of the aneurismal sac is manifested by severe pain and motor disturbances in the distribution of the plexus. The pain at times is unbearable while the muscular contractures and paralyses, according to Oudard, show a tendency to become permanent, even though an operation is ultimately performed. These unfortunate complications do not occur when the aneurism has been cured or improved by conservative treatment. The rapid and uncontrollable increase in the size of an aneurism leading to rupture constitutes an actual risk. Syring reports a case of subclavian aneurism due to penetration by a bullet and associated with damage to the vein in which death from hæmorrhage took place eleven days after the trauma before any operation could be attempted.

Immediate operation is indicated in traumatic subclavian aneurism when blood is lost. It is also justified when the hæmorrhage is intermittent although the loss of blood in each instance is not sufficient to threaten the life of the patient. All agree in the advisability of early operation whenever there is injury to the brachial plexus. It must be remembered, however, that complete paralysis may follow contusion or compression of a nerve trunk without its division or laceration. This was repeatedly observed during the war, in the main trunks of the brachial plexus, complicating lacerated wounds of the arm. Early operation must also be done when continuous increase in the size of the aneurism points to the probability of the early rupture of the sac. In war surgery the necessary débridement of the wounds resulting from high explosive fragments or other agents known to introduce highly infectious material is possible only after satisfactory hemostasis has been carried out. Even when subsequent infection is uncommon, as in penetrating bullet or stab wounds taking place in civil life, some surgeons prefer operation for the ensuing aneurism in every instance. It is precisely in cases of this character, however, that conservative therapy in the absence of any complication is likely to give satisfactory results.

Operations for the relief of aneurism include the excision of the sac (to which reference has already been made), the various forms of ligation, and operations to restore vascular continuity either by the Matas endo-aneurismorrhaphy, or, especially in traumatic aneurism, by suture of the lateral tear in the vascular wall, by end-to-end anastomosis after excision of the damaged segment or by implantation of a segment of the internal saphenous vein between the ends of the divided artery when the length of the gap precludes the possibility of anastomosis without undue tension. Excision or ligation in any form is subject to the risk of secondary hæmorrhage or to gangrene. The former is most frequent after ligation of the largest trunks, especially of the innominate and aorta when the cutting through of the ligature finds the lumen of the vessel still patent. A clot of sufficient length and strength, because of the number and size of its branches, may also fail to follow a ligation of the first part of the subclavian. It is for this reason that the writer suggested in 1912 the ligation of these various branches with the exception of the vertebral.

The suture, anastomosis, or plastic repair of divided arteries advocated especially by Lexer and Hotz and to a certain extent by Bier and Zahradnecky were devised to avert the danger of gangrene. For their success a healthy arterial wall and complete absence of infection are unquestionably essential. When hæmorrhage can be controlled by the application of an Esmarch bandage or by preliminary proximal and distal ligation of the torn or perforated vessel, the operation is relatively without risk. In traumatic aneurism of the subclavian artery the danger of uncontrollable hæmorrhage, either in the course of the operation or subsequently from an insidious or unsuspected infection, is an important factor. Unfortunately, the clinical details in Lexer's essay are very meagre. Yet he mentions one death on the table from failure to check the hæmorrhage from the sac of a subclavian aneurism; a second death from an infected thrombus in a ligated subclavian stump, and a third fatality, also in the presence of infection, twenty-four hours after operation from "myocarditis and sepsis." Five successful cases of operation for traumatic aneurism in arteries of the extremities are cited in which after healing of the wound pressure upon the vessel at the point of suture would, as long as it was continued, obliterate the distal pulse. Bier's admirable essay is much more explicit than Lexer's forty-four operations cited by him for traumatic aneurism of from eight days' to three months' duration which included two aneurisms of the subclavian artery above the clavicle and two of the same vessel below that bone. He mentions the fact that the vessel did not participate in the formation of the aneurism and that bleeding would still continue from the damaged vessel even after compression was made on either side of the perforation. Whenever possible Bier recommends strongly the excision of the damaged portion of the lacerated vessel, together with the ligation of the divided ends of the artery reinforced by overlying suture when those ends are imbedded in reparative tissue. He carefully avoids the sacrifice of all neighboring branches. In no instance was there interference with the distal circulation. The adequacy of the collateral circulation could readily be determined by releasing the constricting tape on the distal side of the aneurism and observing whether blood escaped from the end of the divided artery while proximal compression was still employed. Lexer and several others also call attention to this valuable test. If the collateral circulation is found to be sufficient, ligation of the divided ends of the artery is preferable to suture. The four subclavian aneurisms were treated by ligation of the vessel on either side of the aneurism with tamponade of the cavity of the sac. Of these two died, one from sepsis, the other from a thrombus extending up the adjacent common carotid and interfering with the cranial circulation. In the forty-four cases the vessel was repaired in thirty, fifteen by lateral suture, and fifteen by end-to-end anastomosis including three with an intervening saphenous segment. In the entire series there were two deaths, both occurring in subclavian aneurism as previously mentioned.

In the experience of Lexer and Bier, although the number is small the operation for traumatic subclavian aneurism shows a very high mortality. An even higher mortality is mentioned by Braithwaite, who reports that "of twenty-eight recorded cases of penetrating and perforated injuries of the subclavian vessels, in nearly all of which both the artery and vein were involved, in the few in which an attempted excision was made, a fatal issue resulted on the table in every case." Furthermore, of the three cases reported by the writer, of which two had been in his care prior to operation by another surgeon, two died within twenty-four hours after the operation from excessive hæmorrhage. In the one that survived the symptoms of a cerebral embolus that permanently weakened the right upper extremity, immediately followed the operation and before the wound had entirely healed the physical signs of an extensive pulsating aneurismal varix developed at the site of the original aneurism. The operation in this patient is said to have lasted nearly five hours.

Hotz, quoted by Lexer, refers to the occasional persistence of cyanosis, coldness, and sensory disturbances after ligation of large arterial trunks and is an enthusiastic advocate of vessel suture, reporting six cases involving the common carotid, the axillary and femoral, in three of which repair by transplantation of the segment of the internal saphenous vein was done. In the carotid aneurism secondary hæmorrhage occurred requiring the ligation of the vessel on either side of the aneurism without subsequent disturbance of the cerebral circulation. Of the six cases none involved the subclavian vessels.

Zahradnecky, also quoted by Lexer, has collected 420 cases of traumatic aneurism treated either by ligation or by suture. Of the former, 11.6 per cent. developed gangrene; of the latter, only 3.8 per cent. developed gangrene. The mortality was 7 per cent. and 7.7 per cent. respectively. He emphasizes the advantages of early operation in cases closed by suture, recommending that it be done between the third and sixth week. He prefers ligation where adequate collateral circulation can be demonstrated, especially in the presence of infection. His individual experience comprises fifty-two cases, of which three recovered spontaneously. Of the remainder, twenty-eight were treated by ligation and twenty by suture. The cases treated by ligation included two of the subclavian, the result of the treatment of which is not mentioned. In six seriously septic cases gangrene developed with a fatal termination in five. Of the twenty cases treated by suture, thirteen were treated by lateral suture, five by circular end-to-end anastomosis and two by the transplantation of a segment of a vein. In an aneurism of the subclavian artery treated by end-to-end anastomosis, four centimetres of the artery being removed, the patient died of "anæmia." The two venous transplantations were done in the external iliac. Gangrene developed in each instance with a fatal termination.

It is perhaps well to emphasize that the operative treatment of spontaneous subclavian aneurism differs from that of the traumatic variety. Proximal ligation is in the former variety the operation of choice, supplemented by subsequent distal ligation with or without excision of the sac if the primary operation has been unsuccessful. In aneurisms of the first portion of the vessel ligation of the innominate must be done. In aneurisms of the second or third portion the ligation of the first part of the artery may be supplemented by ligation of the internal mammary and thyroid axis. If the artery proximal to the aneurism is atheromatous distal ligation as close as possible to the aneurismal sac is justifiable. Pearson, in a case of this kind, permanently cured an aneurism of considerable size by this procedure after an attempt to ligate the first part of the artery disclosed an extensively sclerotic condition in which the artery was adherent to its sheath, and to the cervical plexus.

The exposure of the innominate or of the first part of the subclavian is facilitated by the resection of the inner end of the clavicle with or without the adjacent part of the manubrium of the sternum. In the ligation of the deeper part of the left subclavian a satisfactory exposure of the vessel can be secured through the posterior mediastinum.

All kinds of absorbable and non-absorbable material including chromic gut, silk, kangaroo tendon, linen bands, fascial strips, together with special clamps such as those devised by Halsted, have been used in different varieties of ligation with equal success. The form of knot has also varied, the double ligature being favored. Successful ligation of the abdominal aorta is still relatively an unsolved problem. The patients of Hamann, who used braided silk, and of Vaughn, who used tape, survived the operation and lived for six months and two years respectively. At present fascial strips, especially in the ligation of large vessels, are generally preferred. Campbell, who has used this material in the ligation of the common carotid in three instances and of the popliteal in one, states that "simple ligation and treatment by other methods has not given nearly such good results in my hands or in the hands of my colleagues."

The operative treatment of traumatic subclavian aneurism consists in the exposure and temporary constriction of the artery both proximal and distal to the aneurism. On the right side the first part of the subclavian, or, if necessary, the innominate can be exposed through a resection of the inner end of the clavicle and adjacent manubrium as in the operation for spontaneous aneurism. The first part of the axillary is readily accessible after separation of the pectoralis major and inner edge of the deltoid above the tendon of the pectoralis minor. The clavicle is now sown across along the inner margin of the trapezius attachment and reflected downward after division of the sternocleidomastoid tendon. This gives an excellent exposure of the scalenus anticus and of the artery on either side of it together with the brachial plexus above it. Whether ligation of the two ends, after excision of the intervening segment is carried out or some form of suture or anastomosis is done, is then determined by the test already described. If infection is present or likely to develop, or if, in a perfectly clean wound the collateral circulation proves adequate, ligation must be the operation of choice. If suture or anastomosis is attempted, the ligature on either side of the sutured artery should be left *in situ* untied. If secondary hæmorrhage occurs satisfactory and immediate hemostasis can be effected by the tightening of these ligatures.

Operations for traumatic aneurism involving the first part of the left subclavian artery are extremely difficult. The choice between the anterior or posterior approach through which a ligature can be placed around the artery distal to its origin from the arch but proximal to the aneurism depends upon its relation to the aneurismal swelling as shown by the X-ray. The placing of the distal ligature presents no special difficulty. It is in this

variety of intra-thoracic aneurism that Bier suggests the tamponade of the aneurismal sac after ligatures on either side have been inserted and tightened.

The great risk of this operation, even in the absence of infection and in the absence of plexus complication, perhaps justifies conservative treatment. In Case III it was the intention of the writer to ligate the first part of the right subclavian artery within six or eight weeks after the trauma if by that time the aneurism had persisted or increased in size and to supplement it later on, if necessary, by ligation of the first part of the axillary. In Case IV ligation of the third part of the subclavian supplemented if necessary by ligation of the axillary distal to the aneurism was about to be carried out when the patient insisted on leaving the hospital. In Case V which, at no time, was seen by the writer, preliminary or actual ligation of the artery on either side of the stab wound might have averted a fatality.

The resection of the clavicle in these operations does not impair the ultimate strength of the shoulder girdle or prevent the return of the patient to laborious occupation. Even non-union or a subsequent osteomyelitis with necrosis extensive does not seem to interfere with the return of permanent strength in the upper extremity.

CASE I.—Spontaneous aneurism of the third part of the right subclavian reported by the writer in 1912.

CASE II.—Reported by Doctor Colp; referred to by the writer.

CASE III.—Adult, aged thirty years. Admitted to the Knickerbocker Hospital in May, 1931, with a bullet wound over the middle of the right clavicle from which there had been extensive hæmorrhage. He was transfused several times. Two days afterward when first seen by the writer the patient was in good condition. At that time a soft blowing murmur was heard at the junction of the middle and outer third of the clavicle and also above the bone. There was a weakness but no actual paralysis of the muscles of the right upper extremity with complete absence of sensation in all the fingers of the right hand. Ten days later both the muscular weakness and the loss of sensation had disappeared. The murmur loudest over the site of the wound was transmitted along the right subclavian and the right common carotid as far as the thyroid cartilage. There was expansile pulsation above the middle of the clavicle which was circumscribed with an infraclavicular thrill most pronounced below the middle of the bone.

During the following four weeks both murmur and thrill decreased markedly in intensity and extent. He complained of inability to regain his strength and is still underweight. During the following month these symptoms continued to improve including the expansile pulsation. The patient then passed into the hands of another surgeon who performed an immediate operation in another hospital. When seen by the writer four months after the injury and about two months after the operation, an operative scar was found extending from the junction of the third right costal cartilage and the sternum upward and outward along the sternomastoid attachment on the clavicle and then downward and outward to below the level of the pectoralis major one inch from the deltoid. In the upper concavity of this scar was a swelling three inches in diameter, having expansile pulsation and an extensive typical rasping murmur generally found in arteriovenous aneurisms. This is transmitted along both carotids to the skull and over the left side of the chest. It is also heard over the inferior angle of the scapula in the back. For two weeks after the operation patient states that he had paralysis of the left side which responded to electrical treatment. He still complains of weakness and numbness of the left leg and arm and of the left side of the neck, ear and scalp.

Six months later these various symptoms are somewhat more advanced and the patient is unable to do any heavy work.

CASE IV.—This patient was admitted to the Knickerbocker Hospital in July, 1930, with a stab wound over the upper part of the deltoid muscle. The healing of the wound was complicated by the discharge of a considerable amount of clotted blood, although no symptom of aneurism was noticed. Two months later, returning for observation, a pulsating swelling with a murmur extending down along the axillary artery was noticed and the patient was admitted to the hospital for operation. Becoming dissatisfied, he left the hospital voluntarily and after entering one of the city hospitals was operated on without delay. Evidently the operation consisted in some effort to reestablish arterial continuity. The patient died in less than twenty-four hours after the operation chiefly from the loss of blood sustained.

CASE V.—Patient admitted to one of the city hospitals some years ago with a stab wound over the right clavicle, in which the symptoms of a pulsating swelling are said to have rapidly developed. In an operation to reestablish arterial continuity, the patient lost so much blood from the rupture of the sac that he died within twenty-four hours.

BIBLIOGRAPHY

- Ashhurst, A. P. C.: *ANNALS OF SURGERY*, 1920, 71, 99.
 Ballance, C.: *Tr. Roy. Med. Corps*, London, 1918, 31, 417-419.
 Barling, G.: *Bristol Jour. Surg.* 1918, 514.
 Bier: *Deut. Med. Wochen.* 1915, 122.
 Brown, H. J.: *Brit. Med. Jour.* 1918, 1, 617.
 Brown, S.: *N. Zealand M. J.* 1919, 18, 71.
 Caldwell, S. L.: *Surg. Clin. North Americ.* Oct. 3rd, 1930, 973-977.
 Campbell, J. M.: *South. Med. Journal*, Birmingham, 1926, 19, 795-798.
 Cotte, G.: *Lyon Chir.* 28, 457-458.
 Eliot, E.: *Tr. Am. Surg. Ass.* 1912, 30, 381-400.
 Flor, V. E.: *Wiener Klin. Woch.* 1915, 28, 76.
 Gaudiani: *N. Y. Med. Rec.* 1915, 87, 331.
 Griffith, C. A.: *Brit. Jour. Surg. Bristol*, 1915-1916, 3, 299.
 Guleke: *Zentrall. f. Chirur.* 1916, 43, 660-662.
 Halsted, W. S.: *Lyon Chir.* 1921, 18, 1-6.
 Hamann, C. A.: *Tr. Am. Surg. Ass.* 1918, 36, 495-500.
 Haubold, H. A.: *N. Y. Med. Rec.* 1916, 89, 581.
 Heinlein: *Zentral. fur Chir.* 1916, 43, 729-733.
 Herrick, F. C.: *Tr. Am. Med. Ass. Chicago*, 1918, 71, 2120-2122.
 Hertzler, A. E.: *Surg. Clin. North Amer.* 1923, 3, 1507-1512
 Hotz. (See *Lexen*.)
 Jastram: *Deut. Med. Woch.* 1921, 47, 369.
 Kirchner, C. G.: *Jour. Miss. Med. Ass.*, 24, 135-138.
 Lagoutte: *Bull. et Mem. Soc. de Chir. de Paris*, 1921, 42, 1243-1246.
 LeDentu: *Bull. et Mem. Soc. nat. de Chir. Paris*, 1924, 940-944.
 Lehman, R.: *Monat. fur Unfall. Leip.* 1924, 31, 78-80.
 Lexen, E.: *Zeit. fur Chir.* 1916, 135, 439-474.
 McClure, J.: *Brit. Jour. Surgery*, 1918, 436.
 Moore, C. A.: *Lancet*, London, 1922, 1, 1045.
 Neuhof, G.: *Surg. Gyn. & Obst.* 1918, 26, 324-330.
 Oudard: *Arch. de Med. et Pharm. nav. Paris* 1919, 107, 346-362.
 Pfanner: *Wien. Klin. Woch.* 1922, 35, 308.
 Reid, M. R.: *Archives of Surgery* 12, 1-74.
 Riedel, K.: *Deut. Med. Woch.* 1917, 43, 230-232.

- Smith, R. J.: Wright. Med. Jour. Australia 14, 754-755.
Stewart, G. N.: Jour. Experim. Med. Lancaster, Pa., 1915, 22, 695-700.
Syring: Munch. Med. Wochen. 1915, 18.
Thompson, J. E.: ANNALS OF SURG. 1915, 61, 643-657.
Tuffy, A. H.: Lancet, London. 1918, 902.
vonRydygier: Zentral. fur Chir. 1917, 44, 89.
vonHaberer, H.: Archiv. fur Klin. Chir. 1916, 611-693.
White, J. S.: Brit. Med. Journal 1918, 2, 131.
Wolff, E.: Beit. z. Klin. Chir. 1908, 762.
Wohlgemuth, H.: Zentral. fur Chir. 45, 383-387.
Zahradnecky: Zentral. fur Chir. 1916, 62.

SURGICAL TREATMENT OF POST-OPERATIVE SAPHENOUS THROMBOPHLEBITIS

BY HARVEY B. STONE, M.D.,
OF BALTIMORE, MD.

SO SIMPLE and so obvious is the idea presented in this paper that it well may seem to be saying an undisputed thing in a very solemn way, nor can the first blush of originality be urged as an excuse since Homans¹ has already brought the same idea before this Association. Nevertheless, although many surgeons in private conversations have advanced no objection to the desirability of ligating thrombosed peripheral veins that develop after operations, they apparently are reluctant to put the idea into practice. It is in the hope of persuading others to carry the principle into actual effect that this paper is written. As a basis for the argument a few brief case reports will be presented.

CASE I.—Male, fifty-one years old, Union Memorial Hospital, No. 17679. Operated upon by the writer for left inguinal hernia, May 8, 1930, Dr. J. S. Davis removing a painful callus from the left foot at the same time. Uneventful convalescence until the ninth day, when there developed pain in the left calf, elevation of temperature to 100° and a palpable, hard, tender vein. *Diagnosis*.—Thrombophlebitis in a branch of the saphenous vein. An ice bag was applied to the leg and rest in bed continued beyond the usual time for convalescence from such an operation. The patient was allowed to go home on the nineteenth day after operation, under protest, because of his urgent insistence on leaving. Temperature at that time was practically normal and the pain had disappeared. The next day a definite, small, pulmonary embolus occurred with a distinct area of infarction. Patient recovered without further incident.

CASE II.—Female, fifty-three years old, Union Memorial Hospital, No. 7109. Operated upon by the writer for cholecystitis and cholelithiasis November 27, 1929. Temperature gradually declined after operation but not quite to normal. On the fourteenth day there was pain in the left leg, rise of temperature to 100.2°, palpable, tender, saphenous vein. Temperature continued to rise to 103°. Pain and tenderness and palpable cord advanced day by day to the groin in spite of ice bags, slight elevation of leg and rigid confinement to bed. The whole leg became swollen. Condition gradually improved until by the thirty-eighth day the swelling and pain had largely subsided, the temperature was practically normal and the patient was allowed up in a chair. She was considered nearly ready to go home when a sudden and fatal pulmonary embolus occurred on the forty-third day after operation.

CASE III.—Reported by Bunn.² The patient, a woman of fifty-five years, had recent injection treatments with a sugar solution for varicose veins. Following the treatment she developed a soreness along the course of the long saphenous vein and two attacks that were regarded as clearly due to pulmonary embolism. "Plans were being made to tie off the saphenous vein as soon as the patient's condition justified manipulation." The next morning, however, a final and fatal embolus occurred, the consultant actually hearing what he believed to be the sounds made by the passage of the embolus through the heart.

CASE IV.—Reported by Freeman.³ A woman of sixty-one years with varicose veins developed thrombophlebitis in the left saphenous vein. Under rest and hot packs for

five days the condition apparently improved greatly and the patient was allowed up in a chair. She developed a sudden dyspnoea and cyanosis and died in a few minutes. Autopsy revealed a long thrombus in the pulmonary artery regarded as a cast of the saphenous vein. The femoral and iliac veins and the vena cava were found normal at autopsy, the only vein involved being the saphenous.

Doubtless an extensive search for similar cases would bring to light many instances of embolism originating with thrombophlebitis of the saphenous veins but these four cases, all occurring in the past two or three years, are ample to prove the possibility of such grave accidents taking place. To argue that thousands of instances of thrombophlebitis occur without embolism is beside the point. The point is that embolism—rarely, to be sure, but none the less definitely—may convert a relatively simple situation into a dangerous or fatal one. We have been urged not to be satisfied with the ninety-nine good results but to struggle for the salvation of the hundredth case. Here is an opportunity to practice that doctrine. The ease and safety with which embolism may be guarded against when the original thrombus is limited to the saphenous system of veins is another strong reason for active intervention rather than the passive attitude now customary. Under local anæsthesia it is an extremely simple matter to ligate the saphenous in the thigh an inch or two below its entrance into the femoral. Such a procedure takes only a few minutes, causes very little pain and can be done even if the patient is extremely ill without adding appreciably to his burdens. The writer has been content to doubly ligate the vein with fine silk *in situ*, without dividing it, as a measure to prevent the occurrence of emboli. This, of course, can be done only before the process of thrombosis has spread entirely through the course of the saphenous and into the femoral—as did happen in the second case cited above. When the extent of the thrombophlebitis in the superficial vein is limited, it is not a great addition to the operation to excise the whole involved area and this would seem a step toward the quicker and more complete recovery of the patient.

The following cases may be cited to illustrate the execution of the plan advocated in this paper.

CASE A.—Female, thirty-eight years old, Church Home and Infirmary, N. S., No. 328. Automobile accident with fracture of pelvis and ribs, cranial contusions, *etc.* During convalescence, after being in bed about six weeks, the patient developed pain, tenderness and a palpable cord on the inner side of the left calf with a slight elevation of fever (99.5)°. The thrombosis spread slowly and in about four days reached to and a little above the knee. The patient, who was a surgical nurse in charge of an operating room, was advised to have the vein ligated and the reasons for this explained. She accepted and the operation was carried out under local anæsthesia. The saphenous was ligated below Scarpa's triangle but the thrombosed portion was not removed. Healing was *per primum*, there was no addition to the time the patient would have been confined to bed, even if the ligation had not been done, and recovery was complete.

CASE B.—Female, sixty-nine years old, Church Home and Infirmary, N. S., No. 583. The patient was recovering from a one-stage abdominoperineal resection of the rectum and sigmoid, done by the writer on June 20, 1931. On the seventeenth day after operation she began to have pain in the calf of the left leg and a hard, tender cord could be

SAPHENOUS THROMBOPHLEBITIS

felt in the position of the internal saphenous branch below the knee. The process spread slowly upward to the knee and on the twenty-first day after operation—the fourth day of the thrombotic process—the saphenous was ligated under local anæsthesia below Scarpa's triangle. The patient made an uneventful subsequent recovery and is still living and well.

CASE C.—Female, forty-three years old, Church Home and Infirmary, N. S., No. 1618. The patient was on the service of Dr. Guy L. Hunner, who had performed a right nephrectomy on November 24, 1931. She was recovering well when, about three weeks after the operation, she developed a thrombophlebitis of the lower portion of the left long saphenous vein close to the internal malleolus. Doctor Hunner was good enough to ask me to see her because of my interest in such cases. The area of involved vein was small, being about four centimetres in length. The patient was advised to have the whole involved segment of vein resected. This was done under local anæsthesia and recovery took place without further incident.

These few cases are recorded, not, of course, to serve as the basis for any generalization, but to illustrate the sort of situations in which surgical interference may be called for. It is the writer's strong conviction that such surgical intervention is not only justifiable but highly desirable. It is difficult to see any real argument against it and there are obvious good reasons for it. The comparative rarity of serious embolism from saphenous thrombosis is the probable explanation of the customary passive attitude on the part of the surgeon. When attention is called to the existence of such a danger and the simplicity of the measures necessary to avert it, there would seem no objection to a revision of our usual "laissez faire" position and the assumption of a more direct intervention.

The subject of this paper restricts its proper field to consideration of thrombophlebitis occurring in the saphenous veins only and as a post-operative complication. There are, however, two extensions of the idea that should be discussed briefly. What has been said applies with equal force to the much more rare thromboses of other superficial peripheral venous systems as those of the arm for instance. When one comes to deal with the deep pelvic veins, however, the situation is distinctly different. Here the approach to the diseased vessel is a much more formidable procedure. The exact location of the trouble may be in itself a problem. The question of anæsthesia is by no means simple. On the other hand, deep pelvic thrombosis is far more common as a post-operative complication than is the similar process in the saphenous system and is probably the principal cause of embolism after operation. The writer believes that serious thought should be given to the question of direct surgical intervention in such cases. The day may come when we shall regard them also as suitable for prophylactic ligation of the thrombosed veins.

A second enlargement of the theme of this paper would take into its scope thrombophlebitis developing in conditions other than post-operative. The writer has applied the idea in a woman late in pregnancy with an extensive saphenous thrombosis. Her obstetrician was concerned lest the struggles of labor should dislodge the clot, and agreed to operative treatment. In this

instance the saphenous was ligated as usual and then the whole thrombosed segment of vein was dissected out. The patient went through her delivery without difficulty. Homans,¹ in the paper referred to earlier, advocating the ligation and excision of thrombosed varicose veins, refers to a similar case. This woman, four months pregnant, had already had evidence of multiple, small, pulmonary emboli. Thrombosed veins were removed from the leg under local anæsthesia, the emboli ceased and the pregnancy continued undisturbed. It would seem, therefore, that saphenous thrombosis during pregnancy presents another indication for ligation of the veins. But if the reasons be sound for intervention when veins become thrombosed after operation or during pregnancy, why not apply them to peripheral thrombophlebitis generally? Why put people to bed for weeks, on a passive or expectant form of treatment, when there is always the possibility of a clot getting loose? The two cases cited from the literature earlier in this paper prove that this possibility does at times actually happen. When a patient presents himself for treatment with thrombosed veins in his leg, why not perform the simple operation of ligation under local anæsthesia and eliminate the chance of embolism?

BIBLIOGRAPHY

- ¹ Homans, John: Thrombophlebitis of the Lower Extremities. *ANNALS OF SURGERY*, p. 641, May, 1928.
- ² Bunn, W. H.: Sounds Produced by an Embolus Passing through the Heart. *Jour. Am. Med. Assn.*, vol. xcvi, p. 101, July 11, 1931.
- ³ Freeman, Walter: Pulmonary Embolism. *Jour. Am. Med. Assn.*, vol. xcvi, p. 1629, November 28, 1931.

AZYGOS VENOUS SYSTEM IN ITS RELATION TO SEPSIS

By EDWIN BEER, M.D.

OF NEW YORK, N. Y.

IN THE following paper, I should like to call attention to a pathological and clinical condition, which, though apparently very unusual, may be much more common than is realized. By placing in the literature cases observed by me, and thus calling attention to this condition, perhaps other clinicians and pathologists may be reminded of similar cases, which they have seen and have had trouble in interpreting. As far as the literature is concerned, apparently nothing has been published on this subject.* One always hesitates to publish a clinical case *in extenso*, unless it illustrates a new clinical picture, especially before a society such as the American Surgical Association.

CASE I.—Some years ago, a patient, a male of forty-one years, was seen by me suffering from varicose veins in the left thigh, with a thrombophlebitis in the left saphenous vein. The patient was running a mild temperature and physical examination showed a definite involvement of the left superficial saphenous system with gradual extension into the femoral and iliac veins on this side. His leg became swollen; blood culture was negative, though the temperature rose to over 103°. Within three weeks of the inception of the infection in the left saphenous vein, the condition extended well up into the trunk, so that the left lower extremity and the tissues of the trunk, particularly the left side of the trunk all the way up into the left axilla, were markedly swollen and œdematous. The right half of the body and the right lower extremity were not in any way affected. The urinary output remained quantitatively and qualitatively practically normal throughout. Towards the end of the third week, the patient began to have tenderness in the right calf, and as the œdema on the left side of the trunk and in the left axilla gradually disappeared, the right leg and thigh became swollen. By the end of the sixth week, the left side of the body had become absolutely normal, and a massive œdema had developed in the right lower extremity, right hip and abdominal wall up to the level of the umbilicus. The temperature still continued, pain was moderate. The temperature was remittent in character, suggesting a mild form of sepsis. Gradually, under rest in bed, elevation of the extremities and local ice applications, particularly at the beginning of the trouble over the femoral and iliac veins, complete recanalization took place, so that the patient, when he was seen seventeen years later, was in every way normal.

This peculiar clinical picture of a mild progressive thrombophlebitis with negative blood cultures, first involving the left side of the body up to the axilla and then the right side of the body up to the navel, presented a picture which was very difficult to interpret. At the time it seemed to me that one was forced to conclude that the patient had a persistent cardinal vein system, or, in other words, a double inferior vena cava, that the disease had extended up one side first, and then as the vein became recanalized, the process developed in the opposite femoral, and ascended up its iliac and its own inferior

* Since writing the above, A. S. Wischnevsky, from the Clinic of Professor Fedoroff, in the *Zentralblatt für Chirurgie*, p. 946, 1932, reports two cases of embolism through the azygos system, following spinal operations.

vena cava. Further consideration of the case in the light of the next patient to be reported *in extenso* has led me to revise the above opinion and conclude that the patient probably had an ascending thrombophlebitis from the femoral to the iliac and thence up the ascending lumbar and azygos minor system on the left side; and subsequently a similar process on the right side with involvement of part of the ascending lumbar and the azygos major, especially in the abdominal cavity.

Persistent double inferior vena cava I have never seen, and, as far as I know, no clinical or autopsy case has been reported. The clinical picture presented by the above unusual case would readily fit in with the second explanation as the azygos vein distribution, which is subject to great variation, may readily lead to such secondary superficial changes in the trunk as were observed in this case.

CASE II.—About six years ago, a somewhat similar case was admitted to the Medical Service at Mount Sinai Hospital and gave the following history. A boy of twelve years, noticed five days before admission, after swallowing what apparently was a chicken bone, a sharp choking sensation, and pain in the right anterior chest, radiating to the axilla and scapula regions. The pain was increased by deep breathing, and apparently was very severe. For four days prior to admission, he had had dyspnoea and cough, and on the day of admission, a protracted severe chill with temperature to 104° . There was marked urinary frequency during the first days, as well as repeated sweats.

On physical examination, the patient was definitely very sick. There was some tenderness in the right flank and right axilla and spasm in the right upper quadrant of the abdomen. At the right base, there was some dullness and diminution in breath sounds, without any râles. There was shock tenderness over the liver. It was thought that the patient had a diaphragmatic pleurisy, but no pleural rub could be localized. The patient complained of some frequency of urination, but no definite renal pathology could be determined. His blood count was 12,800 white blood-cells, with 82 per cent. polymorphonuclears. The patient continued to run septic steeple-like temperature, ranging up to 106.8° , with a chill almost every day. Blood cultures were negative, as were Wassermann and Widal tests. On the second day after admission, a definite œdema was noted over the lower half of the right chest and the adjacent lumbar region. These areas were not particularly tender.

In view of the history of the onset, following the possible swallowing of a foreign body, an œsophagoscopy was done (Doctor Yankauer) and on the right lateral wall of the œsophagus at twenty-four centimetres a definite area covered with exudate was discovered. With the movement of respiration, it seemed as if pus exuded from this area, and it was thought that the patient had a posterior mediastinal abscess, for which surgical consultation was requested.

Fluoroscopical examination of the chest showed no evidence of mediastinal disturbance, and both leaves of the diaphragm, moreover, moved freely. Also progress of barium through the œsophagus was normal. Rectal examination was negative, except for slight tenderness high up, and this with tenderness over the liver and the violent septic febrile course, suggested the possibility of pyelophlebitis. The tenderness, which originally was rather diffuse over the right lower chest and upper abdomen, gradually became more localized over the right chest, and the œdema of the right chest wall persisted. Some tenderness developed over the sixth and seventh dorsal spines. With this, it was noted that on the right side a pleural rub developed over the right lower lobe where the breathing had become bronchovesicular and percussion note dull.

With the diagnosis of fluid in the right chest, an aspiration was performed fifteen days after admission, and purulent fluid withdrawn. During this period, the patient had several hemoptyses, and repeated chills and rapid loss of strength. He coughed up pieces of broken-down tissue, but no elastic fibres were identified. A second œsoph-

agoscopy gave the same findings, and biopsy showed inflamed mucosa. After the positive aspiration of the chest, signs of pyopneumothorax on this side became evident, and about this time signs of consolidation in the left lower lobe developed. An intercostal incision was made with drainage of pyopneumothorax. Culture of the fluid showed *Streptococcus hemolyticus*. The patient died shortly after operation.

The autopsy showed œdema of the right lower chest and an incision in the eighth intercostal space leading to a suppurative pleural cavity. On the left side, in addition, there was evidence of recent pleuritis. The lungs on both sides were covered with exudate from which *Streptococcus hemolyticus* was cultured and both lungs contained numerous small and large abscesses, many of which were on the surface. On the posterior wall of the œsophagus was a punched-out area one centimetre in diameter, which appeared to be a healing ulceration, in which a central perforation (biopsy?) was seen. The latter did not perforate the entire thickness of the œsophageal wall. There were several dilated veins in the submucosa. The vena azygos major underlying the area of ulceration contained an adherent thrombus two centimetres long, which was light brown in color and firm. Microscopical examination of the thrombus showed numerous chained streptococci and many groups of diplococci. In addition, the small veins of the submucosa of the œsophagus about the area of ulceration showed infected thrombi with infiltration of the wall of the veins. The posterior mediastinum was normal. In the pulmonary arteries there were numerous infected thrombi, and in the lungs there were many emboli with abscesses and pleuritis. No foreign body was found in the œsophagus. The hepatic and portal veins were negative, as were the rest of the autopsy findings.

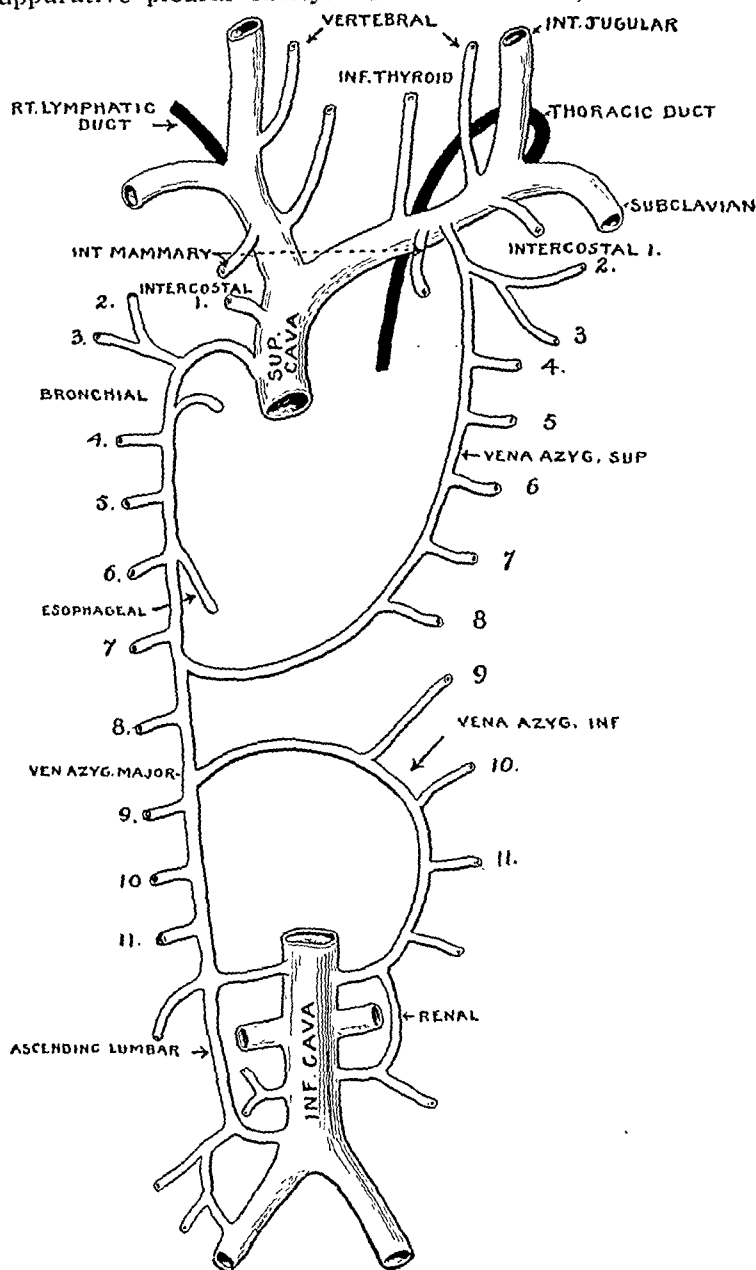


FIG. 1.—According to Cunningham, showing the anastomoses with the iliacs, inferior vena cava, lumbar, œsophageal, intercostal and bronchial veins.

Summary.—Following an œsophageal injury, the patient just reported developed ulceration in the lower end of the œsophagus with thrombophlebitis extending to the azygos major vein, which led to a disturbance in the return circulation in the right chest wall, producing an œdema and subsequently, as emboli were broken off and entered the superior vena cava and the heart, multiple abscesses developed in both lungs, which produced a secondary pleurisy in both right and left pleural cavities. The septic tempera-

ture with indefinite abdominal symptoms and tenderness over the liver had originally suggested the possibility of a portal vein thrombophlebitis, but the development of the localized œdema of the chest wall should have aroused the suspicion of an azygos vein thrombophlebitis, secondary to the ulceration of the œsophagus.

With such an array of symptoms as presented by both these cases, it seems that in the future it may be possible to recognize the clinical picture and possibly establish the diagnosis of the underlying pathology.

In conclusion, I would like to emphasize that in addition to the usual types of sepsis arising in the general circulation, in the portal circulation and

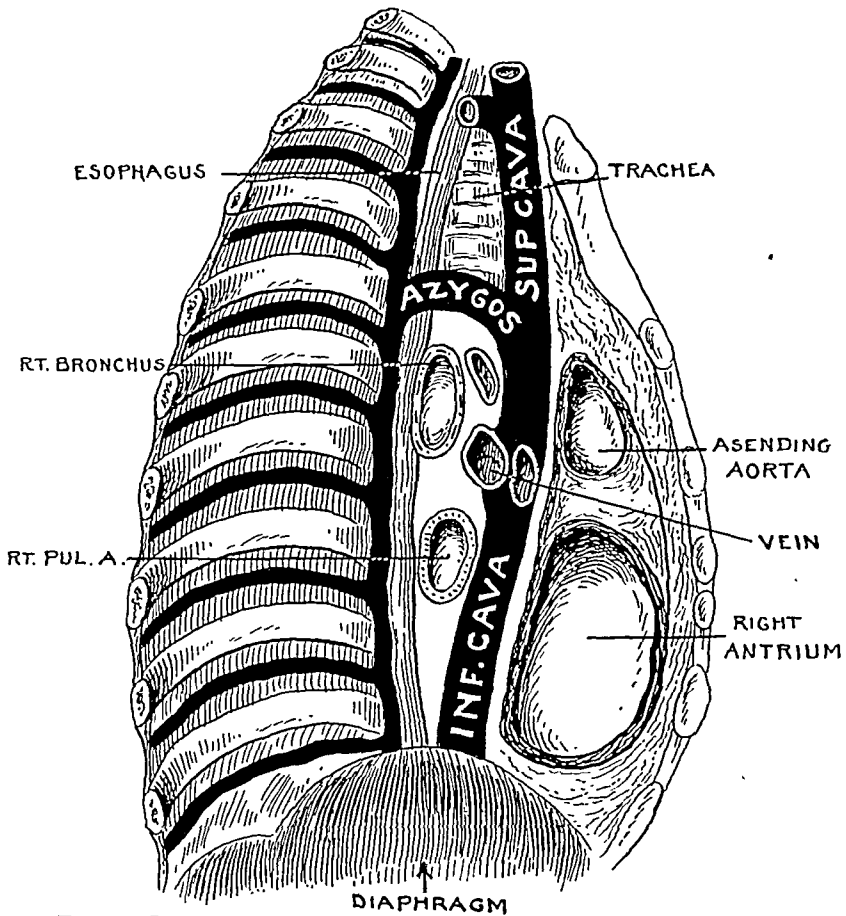


FIG. 2.—Lateral view from Gray's Anatomy showing the anatomical relation between the œsophageal and thoracic veins and azygos major system and anastomosis with the superior vena cava.

in the pulmonary circulation, in the future one must bear in mind the possibility of a sepsis originating in the heretofore disregarded subdivision of the systemic circulation, *i.e.*, in the azygos system of veins. To this description I add illustrations demonstrating the usual distribution of the azygos vein circulation, and their numerous anastomoses, as well as their relation to the abdominal organs and the thoracic organs, and in particular to the œsophagus, and the vertebral column. (Figs. 1 and 2.) I would not be surprised if the radicals of this system are more or less regularly involved in sepsis associated with osteomyelitis of the vertebral bodies, a case suggesting this combination having recently been operated upon on my service.

THE INTRAVENOUS INJECTION OF SCLEROSING SUBSTANCES

EXPERIMENTAL COMPARATIVE STUDIES OF CHANGES IN THE VESSELS

BY ALTON OCHSNER, M.D.

OF NEW ORLEANS, LA.

AND

EARL GARSIDE, M.D.

OF CHICAGO, ILL.

THE injection of varicose veins of the lower extremity with sclerosing agents has become very popular and has largely supplanted operative measures. Many thousands of injections have been made with a relative degree of safety, the incidence of dangerous sequelæ being very much lower than that following operative removal of the veins. The beneficial results obtained by the injection treatment are dependent upon changes in the vascular wall produced by the irritating agents, which in turn cause an obliteration of the dilated vessel. Obliteration of the vessel is accomplished largely by means of a thrombus, but also in part by a fibrosis which occurs in the wall of the vein. As a result of injury to the vein wall, especially in the presence of slowed circulation, as shown by Aschoff,¹ there occurs a deposition of platelets along the altered vessel wall with the formation of a fibrinous thrombus. In spite of the many injections which have been made with sclerosing substances in the treatment of varicosities of the lower extremity, relatively few histological examinations of injected veins have been made. In a still smaller group has a systematic comparative study of the changes which occur in the vein as a result of the intravenous injection of different sclerosing substances been made.

For the purpose of determining more accurately the changes which occur in veins following the injection with sclerosing agents and to compare the effect produced by many of the solutions now employed in the injection treatment of varicose veins, the present investigation was made. In order that carefully controlled observations might be made and as the study is largely a comparative one, the experiments were performed on animals, the dog being chosen as the animal for study. That the results obtained in the present investigation are not strictly applicable to the results which might be obtained in the clinic is self-evident, as the changes in a diseased vein, the contents of which are more or less stagnant, are undoubtedly greater than those which occur in a normal vein, the contents of which are in normal motion. Less marked changes following the intravenous injection of sclerosing agents should occur in the normal veins of the experimental animal than in the patient with varicose veins. That the incidence of thromboses is higher in clinical cases with varicosities is evident, because the slowing of the blood stream, shown by Magnus,² McPheeters and Rice,³ Sicard, Forestier and Gaugier⁴ to be present in varicose veins, permits the "eddy" of the blood stream, which, according to Aschoff,¹ favors thrombosis.

Twenty-seven dogs were used in the present investigation. Four hundred thirty-two injections were made in the twenty-seven dogs (four injections into the superficial veins of each leg). The internal saphenous vein was injected in the hind leg, the first

injection being made on the dorsum of the foot, the second on the anterior aspect of the ankle, the third on the dorso-lateral aspect of the leg, and the fourth on the posterior aspect of the knee. The antebrachial-cephalic vein (Ellenberger and Baum⁶) was injected in the foreleg, the first injection being made on the midportion of the dorsum of the paw, the second on the dorsum of the wrist, the third on the dorso-lateral aspect of the leg, and the fourth in the ante-cubital fossa. The same solution was used for all four injections in the same leg. Following the injections, the vein was compressed for approximately ten seconds, after which no compression was used. In two animals that received four injections of 0.04 cubic centimetre each of pure phenol, death occurred almost immediately after the injection. These two animals were discarded from the series. Three other animals died before any sections were removed. At autopsy immediately after death one section was removed from each extremity, so that four observations were made in each one of the three animals instead of the sixteen which had been planned. Two animals died after one group of sections had been removed and at autopsy another group of sections were removed so that from each one of these eight sections were obtained. This gives a total of 348 veins that were used for study.

The following substances with their respective doses were used for the intravenous injection: Dextrose, 50 per cent., one cubic centimetre; dextrose, 66 per cent., 1 cubic centimetre; invert sugar, 50 per cent., one cubic centimetre; invert sugar, 75 per cent., one cubic centimetre; invert sugar, 75 per cent., and saccharose, 5 per cent., $\frac{1}{2}$ cubic centimetre; sodium chloride, 15 per cent., $\frac{1}{2}$ cubic centimetre; sodium chloride, 20 per cent., $\frac{1}{2}$ cubic centimetre; sodium chloride, 25 per cent., $\frac{1}{2}$ cubic centimetre; sodium salicylate, 15 per cent., $\frac{1}{2}$ cubic centimetre; sodium salicylate, 20 per cent., $\frac{1}{2}$ cubic centimetre; sodium salicylate, 30 per cent., $\frac{1}{2}$ cubic centimetre; sodium salicylate, 40 per cent., $\frac{1}{2}$ cubic centimetre; sodium salicylate, 30 per cent., and sodium chloride, 10 per cent., $\frac{1}{2}$ cubic centimetre; invert sugar, 50 per cent., and sodium salicylate, 10 per cent., $\frac{1}{2}$ cubic centimetre; invert sugar, 75 per cent., and sodium salicylate, 20 per cent., $\frac{1}{2}$ cubic centimetre; quinine and urea hydrochloride, $\frac{1}{2}$ cubic centimetre; iodine, 1 per cent., and potassium iodide, 1 per cent., $\frac{1}{4}$ cubic centimetre; mercuric chloride, 1 per cent., 0.125 cubic centimetre; phenol, 1 per cent., $\frac{1}{4}$ cubic centimetre; and mercuric iodide, 1 per cent., $\frac{1}{20}$ cubic centimetre. As mentioned above, in two animals very small doses (0.04 cubic centimetre) of pure phenol were used, but because it produced immediate death of the animal, it was discontinued. Pure phenol was employed because Dalton⁸ strongly advocated its use in varicosities. Sections were removed after one-half hour, one hour, two hours, six hours, twelve hours, twenty-four hours, forty-eight hours, three days, four days, six days, ten days, fourteen days, twenty-one days, four weeks, six weeks, and eight weeks. Segments of veins were immediately fixed in 10 per cent. formalin solution and subsequently imbedded in paraffin. Hematoxylin and eosin, Mallory's connective tissue, and Weigert stains were made of the sections.

Each section was carefully studied histologically and changes occurring within the lumen and the various coats of the vessel were observed. The changes which occur in the endothelium, in the media and in the adventitia will be discussed separately. Some type of endothelial injury occurred in the majority of the sections examined. Of 348 sections examined, 259 (74.4 per cent.) had some type of endothelial injury. The greater number of changes were found in veins removed on or before the fourteenth day after the injection. (Table I.) Of 255 examinations made at the end of two weeks or earlier, in 224 (87.8 per cent.) there was some evidence of endothelial injury as contrasted with thirty-five (48.4 per cent.) in ninety-four observations made at the end of the third week or later. The substances which produced the highest incidence of damage to the venous endothelium were sodium salicylate, 40 per cent., and a solution of iodine, 1 per cent., and potassium iodide, 1 per cent. (Table II.) Other substances grouped in order of their deleterious effect on endothelium were sodium salicylate, 30 per cent., and sodium chloride, 10 per cent.; quinine and urea hydrochloride; and invert sugar, 75 per cent. and sodium salicylate, 20 per cent.

TABLE I
Summary of Changes Occurring in the Wall and the Lumen of Veins Injected with Sclerosing Agents According to the Interval Elapsing between Injection and Time of Observation

693

Endothelial Destruction.—Of 348 observations, there was some degree of endothelial destruction in 157 (45.1 per cent.). (Fig. 1.) Endothelial destruction was

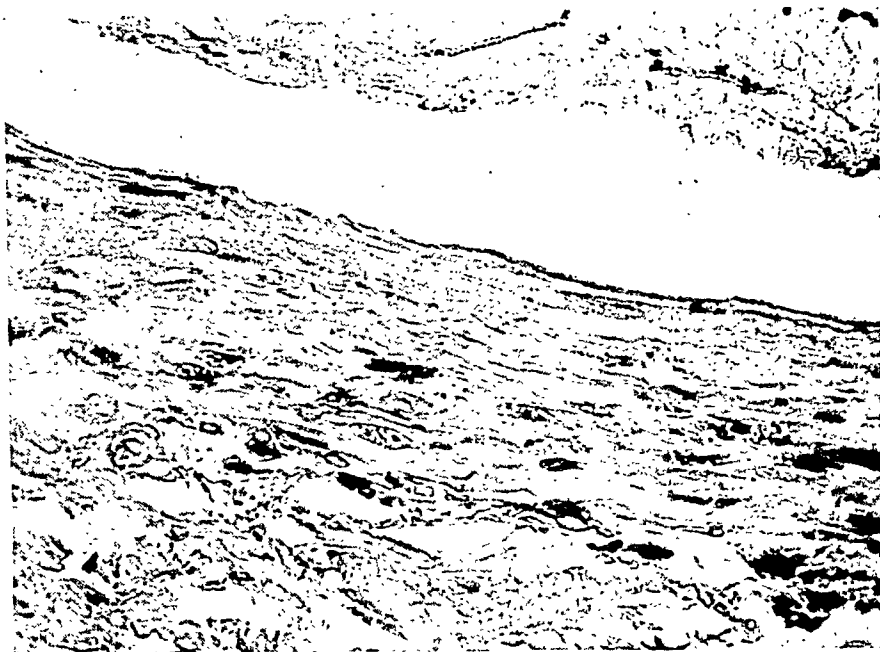
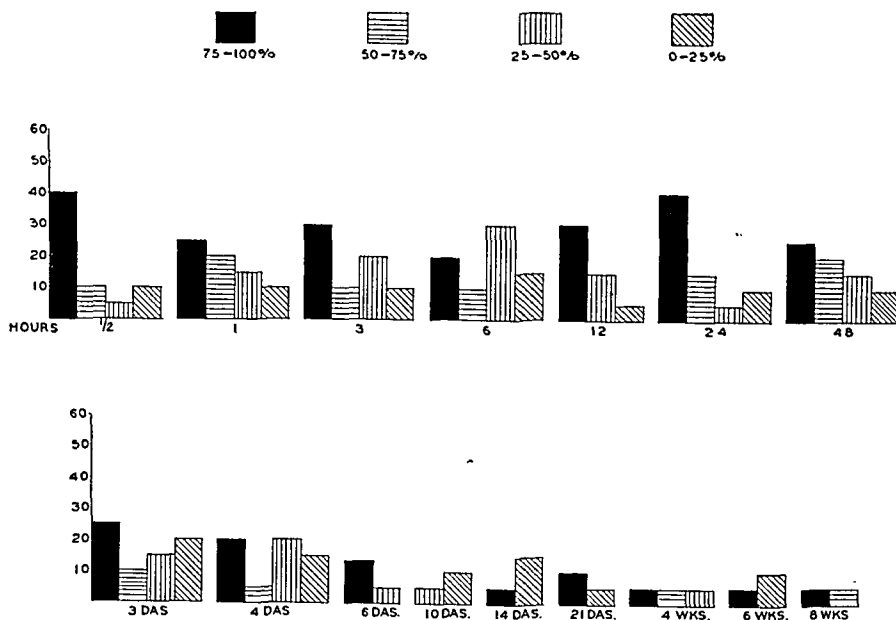


FIG. 1.—(VV-311.) High-power photomicrograph of endothelium of vein injected four days previously with sodium salicylate, 40 per cent., showing complete destruction of endothelium with exposure of media to lumen of vessel.

observed most frequently in the veins removed on or before the fourth day. Of 181 veins extirpated on or before the fourth day, there were 129 (71.2 per cent.) with some



ENDOTHELIAL DESTRUCTION

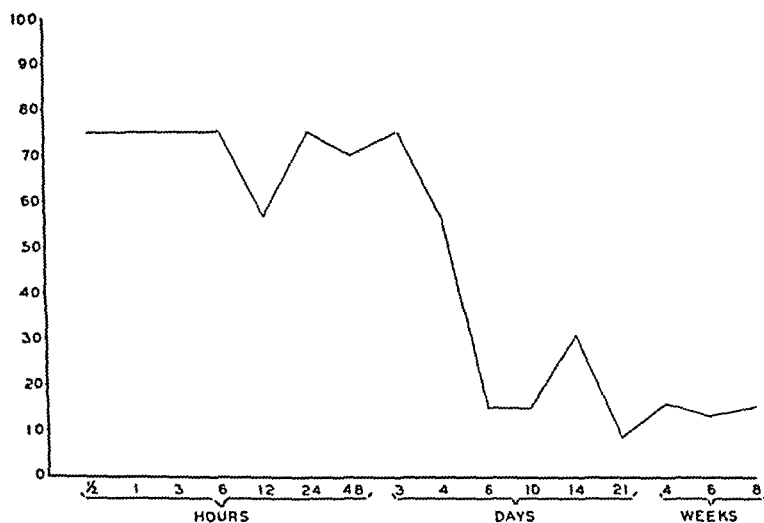
GRAPH I.—Graphic representation of endothelial destruction occurring at the respective time intervals after the intravenous injection of sclerosing agents. The varying degrees of endothelial destruction are also shown.

TABLE II
Summary of Changes Occurring in the Vessel Wall and in the Lumen Following the Intravenous Injection of Sclerosing

	ENDOTHELIUM															MEDIA					ADVENTITIA			
	DESTRUCTION					VACUOLIZATION					EXPOSURE OF NUCLEI					TOTAL INJURY	PROLIFERATION	EDEMA	LEUCOCYTIC INFILTRATION	MUSCLE HYPERTROPHY		HEMORRHEGE	CONNECTIVE TISSUE	DILATATION
	TOTAL	0-25 %	25-50 %	50-75 %	75-100 %	TOTAL	0-25 %	25-50 %	50-75 %	75-100 %	TOTAL	0-25 %	5-50 %	50-75 %	75-100 %									
Dextrose 50%	7.7	22.2	0	0	5.5	61.1	16.6	11.1	16.6	16.6	22.2	0	16.6	5.5	0	72.2	11.1	81.2	11.8	70.5	0	29.3	88.2	
Dextrose 66%	13.3	5.5	27.7	5.5	11.1	52.3	17.6	17.6	11.8	5.8	5.8	5.8	0	0	0	76.4	35.2	77.8	11.1	83.3	0	41.1	88.9	
Invertose 50%	5	18.7	0	6.8	0	55.5	0	16.6	22.2	16.6	33.3	11.1	5.5	16.6	0	72.2	5.5	82.3	5.8	70.5	6.2	18.7	88.2	
Invertose 75%	55.5	11.1	22.2	5.5	16.6	50	0	11.1	27.7	11.1	16.6	0	0	11.1	5.5	77.8	11.1	83.3	0	83.3	0	23.5	100	
Invertose 75% Saccharose 5%	55.5	0	33.3	11.1	11.1	61.1	11.1	16.6	22.2	11.1	0	0	0	0	0	66.6	22.2	83.3	11.1	77.8	18.7	33.3	88.9	
Sodium Chloride 15%	5.8	0	5.8	0	0	37.5	6.2	0	12.5	18.7	25	0	6.2	6.2	12.5	50	6.2	75	6.2	81.2	0	18.7	87.5	
Sodium Chloride 20%	52.3	11.8	17.6	0	23.5	35.2	0	5.8	11.8	17.6	23.5	11.8	0	11.8	0	70.5	11.8	82.3	17.6	70.5	0	23.5	88.2	
Sodium Chloride 25%	66.6	5.5	11.1	5.5	43.3	22.2	0	5.5	16.6	0	22.2	0	11.1	11.1	0	72.2	16.6	82.3	5.5	70.5	6.2	17.6	88.2	
Sodium Salicylate 15%	23.5	23.5	0	0	0	29.3	5.8	11.8	11.8	0	29.3	29.3	0	0	0	64.7	0	76.4	5.8	82.3	0	35.2	88.2	
Sodium Salicylate 20%	35.2	23.5	5.8	0	5.8	35.2	11.8	11.8	5.8	5.8	35.2	29.3	5.8	0	0	76.4	17.6	82.3	11.8	61.2	0	29.3	82.3	
Sodium Salicylate 30%	61.1	16.6	5.5	22.2	16.6	55.5	11.1	16.6	11.1	16.6	5.5	0	0	0	5.5	77.8	11.1	88.9	0	81.9	0	25	94.4	
Sodium Salicylate 40%	76.4	5.8	0	11.8	58.8	23.5	11.8	5.8	0	5.8	11.8	5.8	0	5.8	0	88.2	11.8	82.3	17.6	70.5	0	37.5	100	
Sodium Salicylate 30% Sodium Chloride 10%	64.7	0	11.8	5.8	47.0	29.3	5.8	11.8	11.8	0	0	0	0	0	0	82.3	11.8	76.4	11.8	58.8	6.2	26.6	81.2	
Invertose 50% Sodium Salicylate 10%	35.2	5.8	0	11.8	17.6	41.1	11.8	5.8	17.6	5.8	41.1	11.8	5.8	17.6	5.8	58.8	5.8	82.3	11.8	64.7	0	41.1	94.1	
Invertose 75% Sodium Salicylate 20%	43.3	5	5.5	11.1	22.2	61.1	27.7	16.6	11.1	5.5	33.3	16.6	0	11.1	5.5	72.2	5.5	77.8	0	55.5	0	23.5	77.8	
Quinine and Urea Hydrochloride	66.6	0	11.1	5.5	50	22.2	0	11.1	11.1	0	0	0	0	0	0	77.8	16.6	77.8	27.7	52.6	6.2	37.5	83.3	
Iodine 1%																								
Potassium Iodide 1%	41.1	29.3	5.8	0	5.8	47	11.8	17.6	5.8	11.8	17.6	11.8	0	5.8	0	88.2	17.6	82.3	0	76.4	0	29.3	82.3	
Mercuric Chloride 1%	64.7	23	5.8	17.6	17.6	35.2	0	11.8	17.6	5.8	11.8	0	0	11.8	0	70.5	5.8	82.3	5.8	76.4	0	41.7	88.2	
Phenol 1%	17.6	5.8	0	0	11.8	43.7	0	6.2	18.7	18.7	18.7	0	6.2	0	12.5	56.2	16.7	93.7	0	67.5	0	25	87.5	
Mercuric Iodide 1%	27.7	11	0	0	16.6	50	5.8	11.1	16.6	16.6	22.2	0	5.5	5.5	11.1	72.2	16.6	72.2	11.1	77.8	0	29.3	83.3	

INTRAVENOUS SCLEROSING INJECTIONS

endothelial destruction, whereas of the 167 observations made on or after the sixth day, some degree of endothelial destruction was present in only twenty-eight (16.7 per cent.). (Graph I.) Undoubtedly, the endothelium in the veins examined after the sixth day had the same amount of trauma and a similar degree of destruction as was found present in the veins examined before the fourth day. In all probability, the difference in the amount of endothelial destruction observed before the fourth day (71.2 per cent.) and that observed after the sixth day (16.7 per cent.) is due to regeneration which occurred between the fourth and sixth days. (Graph II.) In the 181 observations made on or before the fourth day, a massive destruction of the endothelium ranging from 75 per cent. to complete destruction of the entire circumference of the vein was observed fifty-three times (29.2 per cent.), whereas in the 167 observations made on or after the sixth day, similar degrees of endothelial destruction were observed only fourteen times (8.3 per cent.). In only one group of all the observations made after the sixth day was the incidence of destruction of the endothelium higher than 16 per cent. Of the thirty-two veins examined fourteen days after the injection of the vein, there was no endothelial destruction in twenty-two (68.7 per cent.). In five (15.6 per cent.), the extent of destruction was graded as being less than 25 per cent. of the cir-

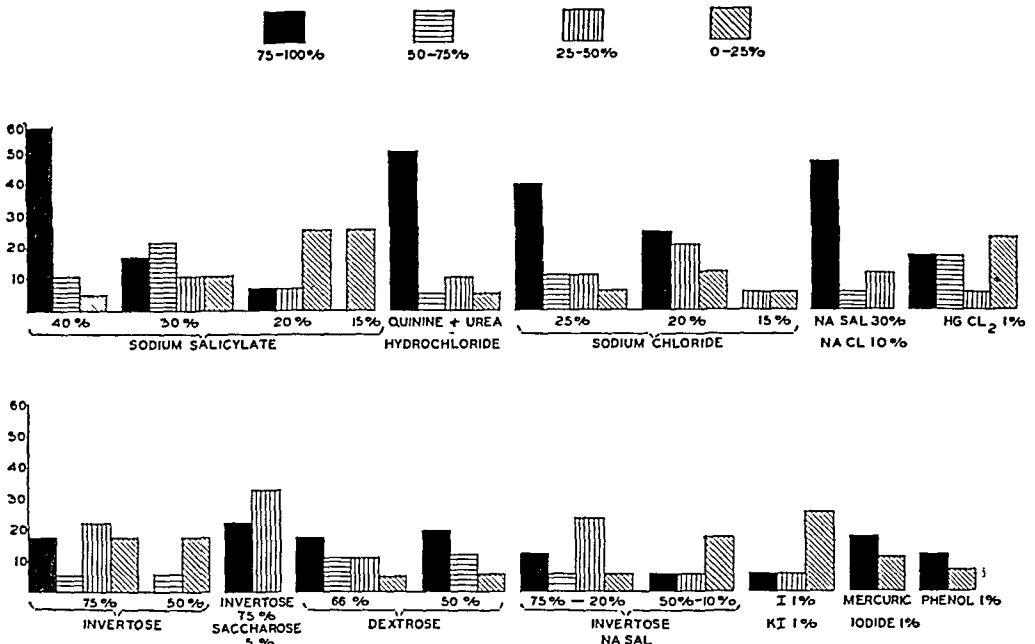


DESTRUCTION OF ENDOTHELIUM

GRAPH II.—Graphic representation of combined amounts of destruction occurring in veins at various time intervals after injection with sclerosing agents.

cumference, whereas in five (15.6 per cent.), it was massive in that more than 75 per cent. of the entire endothelium was destroyed. In four of these, the endothelium was completely destroyed and the lumen filled with a dense organizing thrombus, which was adherent to the vein wall. Of the fifty-three veins removed on or before the fourth day with massive destruction of the endothelium (ranging from 75 per cent. to 100 per cent. of the circumference), in only seven (13.2 per cent.) was there a large thrombus, whereas in the fourteen veins removed on or after six days with a similar endothelial destruction, a large thrombus completely filling the vessel and firmly adherent to the wall was found in thirteen (92.8 per cent.). It is thus evident that the endothelium in most cases except those with massive thrombosis regenerates between the fourth and sixth days after the injection of the vein. The greatest amount of endothelial destruction resulted from the use of sodium salicylate, 40 per cent. Of seventeen observations, some endothelial destruction occurred in thirteen (76.4 per cent.). Of greater significance is that in ten (58.8 per cent.) instances, the endothelial destruction was classed as massive (ranging from 75 per cent. to 100 per cent.). The second most destructive agent was quinine and urea hydrochloride. Twelve (66.6 per cent.) of eighteen observations showed some destruction; in nine (50 per cent.) the endothelial destruction was classed as massive. The least destructive agent was sodium chloride, 15 per cent.;

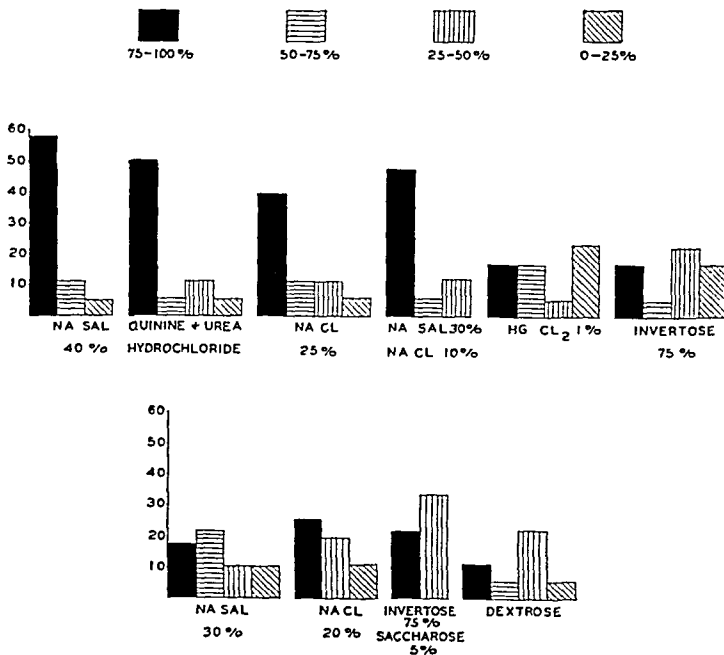
OCHSNER AND GARSIDE



ENDOTHELIAL DESTRUCTION

GRAPH III.—Graphic representation of varying degrees of endothelial destruction produced by the intravenous injection of respective sclerosing agents.

in only one (5.8 per cent.) of seventeen observations was there any evidence of endothelial destruction and this was classed as ranging from 25 per cent. of the circumference of the vein. (Graphs III and IV.)



ENDOTHELIAL DESTRUCTION

GRAPH IV.—Graphic representation of endothelial destruction produced by the ten most destructive of the twenty sclerosing agents employed, arranged in order of the amount of combined destruction.

INTRAVENOUS SCLEROSING INJECTIONS

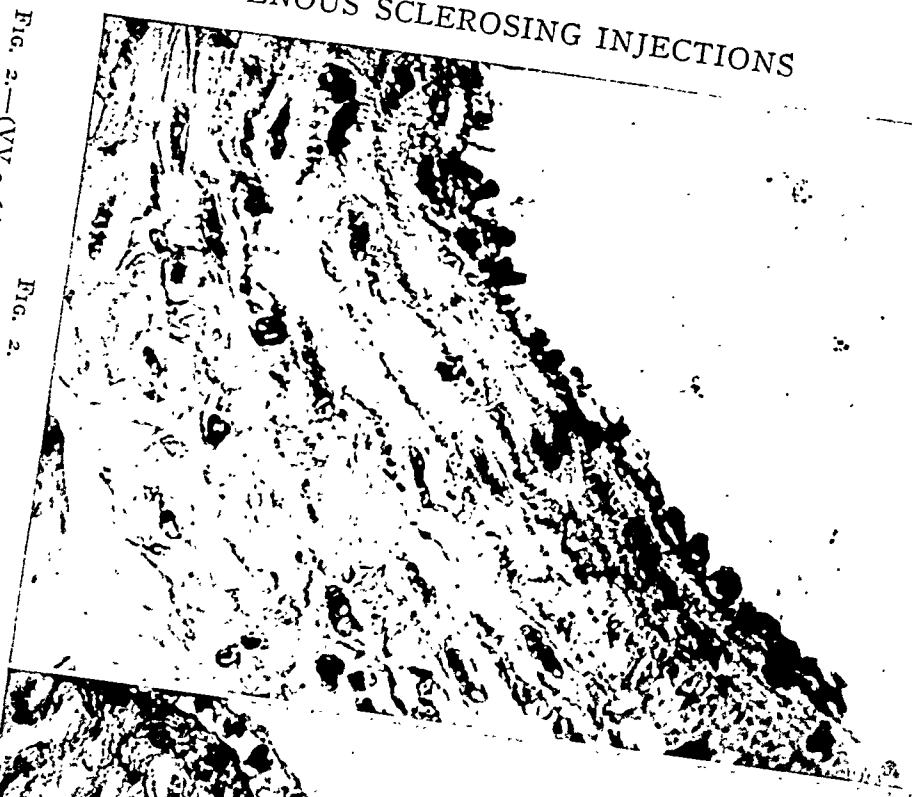


Fig. 2.

Fig. 2.—(VV-236.)

Fig. 3.—(VV-324.)

Fig. 4.—(VV-309.)

High-power photomicrograph of vein injected twelve hours previously with dextrose, 50 per cent., showing partial destruction of cells of the endothelium in that the outer half of the cell is destroyed, leaving the nuclei exposed to the lumen of the vessel.

High-power photomicrograph of vein injected four days previously with invertose, 50 per cent., and sodium salicylate, 10 per cent., showing marked proliferation of the endothelial cells.

High-power photomicrograph of vein injected four days previously with sodium salicylate, 20 per cent., showing marked proliferation of the endothelial cells.

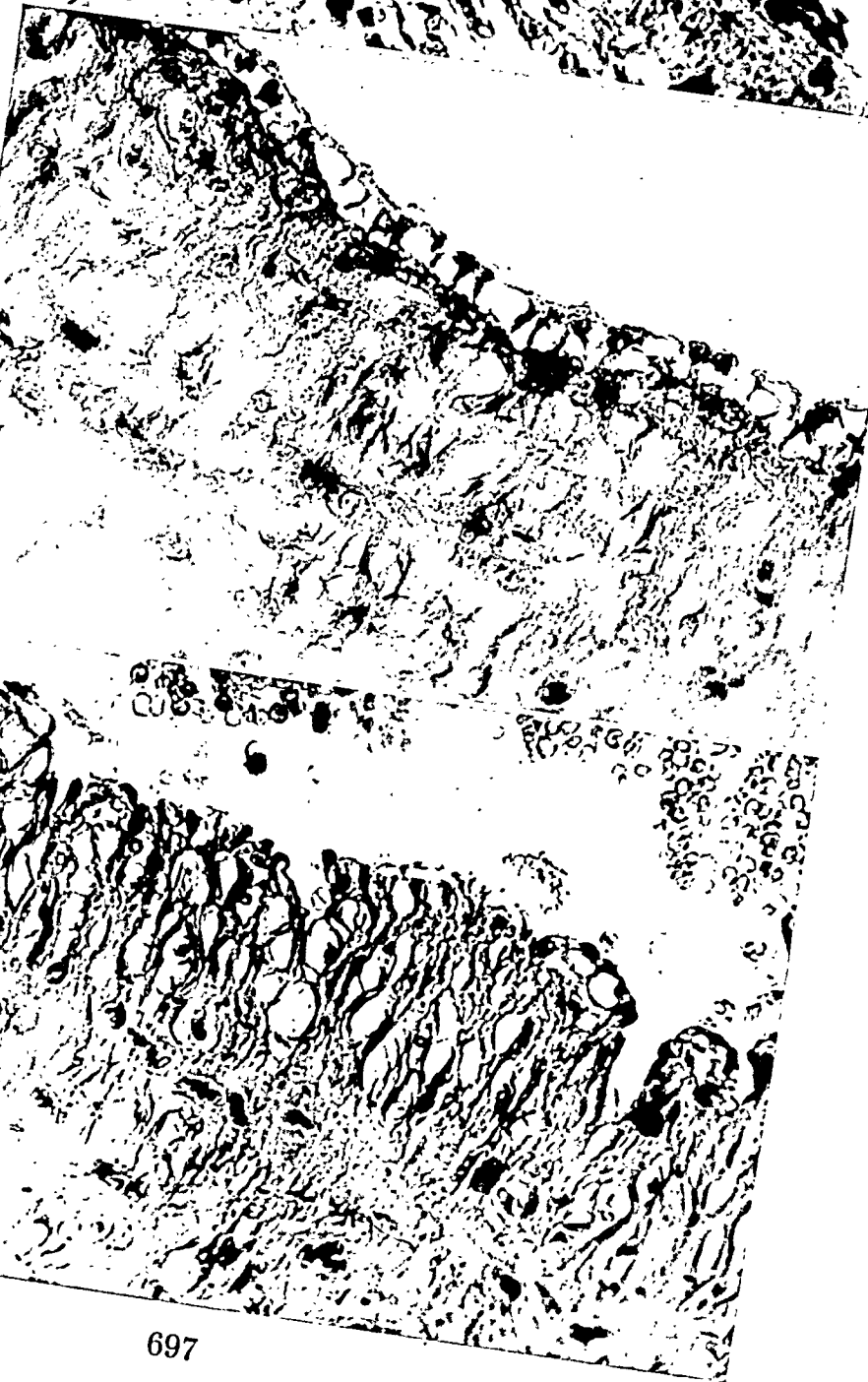


Fig. 3.

Fig. 4.

In addition to endothelial destruction other changes frequently occurred in the intima; *i.e.*, partial destruction of the endothelial cell, so that the nuclei were not covered with cell membrane but were exposed to the vessel lumen and vacuolization of the endothelial cells. In sixty-six (18.9 per cent.) of 348 observations, there was evidence of the endothelial nuclei being "exposed." (Fig. 2.) This change was found in thirty-seven (37 per cent.) of 100 veins extirpated twelve or more hours after the injection, whereas in 248 veins removed after twenty-four hours, it occurred in only twenty-nine (11.6 per cent.). Of the sixty-six instances in which the nuclei were "exposed," thirty-seven (56 per cent.) occurred in veins removed on or before the twelfth hour. "Exposure" of the nuclei occurred most frequently in veins injected with invertose, 50 per cent., and sodium salicylate, 10 per cent.

In addition to the endothelial destruction and "exposure" of the endothelial nuclei, other changes occurred in the endothelium. A rather frequently observed change was vacuolization of the endothelial cells (Fig. 3) which occurred in 151 (43.3 per cent.) of 348 observations. Of 221 veins removed on or before the tenth day, there were 119 (53.8 per cent.) in which vacuolization of the endothelial cells occurred, whereas of 127 veins extirpated on or after the fourteenth day, there were thirty-two (25.2 per cent.) showing this change. The substances which produced the greatest degree of vacuolization were dextrose, 50 per cent.; invertose, 75 per cent. and saccharose, 5 per cent.; and invertose, 75 per cent. and sodium salicylate, 20 per cent. In each, the percentage of instances in which vacuolization was observed was 61.1 per cent. Strangely enough, the degree of vacuolization was least in those veins injected with the more destructive agents; *viz.*, sodium chloride, 25 per cent.; sodium salicylate, 40 per cent.; and quinine and urea hydrochloride. The percentages of observations showing vacuolization in each were 22.2, 23.5, and 22.2, respectively.

Proliferation of the endothelium; *i.e.*, heaping up of the endothelial cells so that the intima consisted of several layers, was not infrequently observed (Fig. 4). Of 348 veins, endothelial proliferation was observed in forty-five (12.9 per cent.). There was no evidence of endothelial proliferation observed within the first six hours following injection. Of the 181 veins removed on or before the fourth day, only eight (4.4 per cent.) showed evidence of endothelial proliferation, whereas of the 167 veins extirpated on or after the sixth day, thirty-seven (22.1 per cent.) showed evidence of endothelial proliferation. This finding corroborates the assumption made above that between the fourth and sixth days endothelial regeneration occurred.

Pyknosis of the endothelial nuclei was frequently observed. In 348 examinations, pyknosis of the nuclei was present in sixty-nine (19.8 per cent.). Of the 203 observations made on or before the tenth day, in seventeen (8.3 per cent.) and of the 145 observations made on or after the fourteenth day in fifty-two (35.8 per cent.) there was evidence of pyknosis of the endothelial nuclei. The greatest amount of pyknosis of the endothelial nuclei was observed in those veins injected with iodine, 1 per cent., and potassium iodide, 1 per cent.; sodium salicylate, 15 per cent.; and mercuric iodide, 1 per cent. The least amount of pyknosis occurred in those veins injected with the most caustic sclerosing agents, such as sodium salicylate, 40 per cent.; quinine and urea hydrochloride, and sodium chloride, 25 per cent. This was undoubtedly due to the fact that in these veins, because of the extensive destruction, no endothelium remained to show the less destructive changes.

CHANGES IN THE MEDIA

Edema.—One of the most frequently encountered changes in the media was œdema (Fig. 5), which occurred in 289 (83.7 per cent.) veins of 348 extirpated from one-half hour to eight weeks after the injection of sclerosing substances. Of 283 veins extirpated at the end of or before the third week following the injection, 278 (98.2 per cent.) had œdema, whereas of sixty-eight observations made four weeks or later after

INTRAVENOUS SCLEROSING INJECTIONS

the injection, there were only eleven (16.1 per cent.) with œdema. (Graph V.) All of the veins examined from one-half hour up to four days after the injection of the

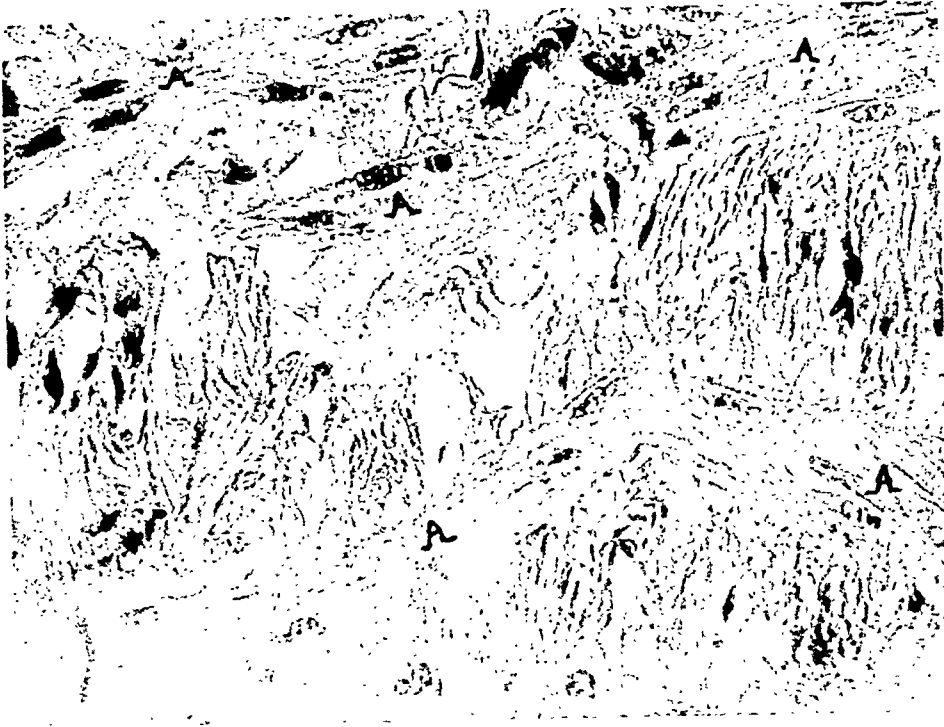
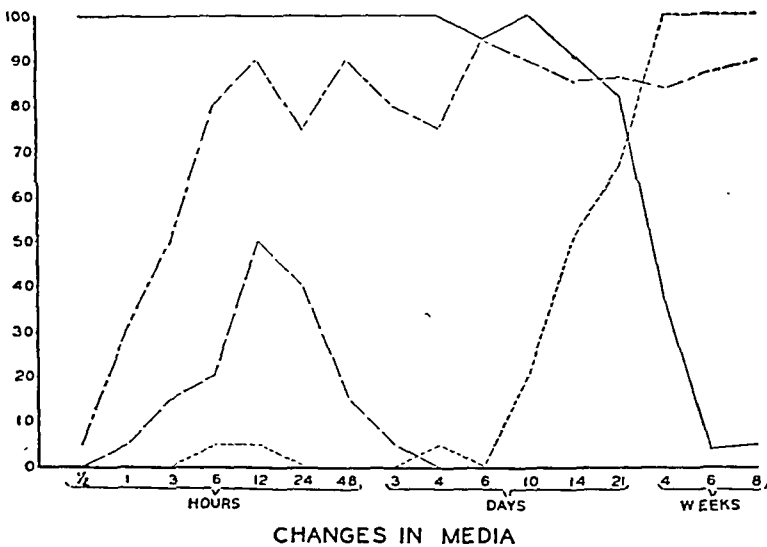


FIG. 5.—(VV-454.) High-power photomicrograph of media of vein injected six weeks previously with sodium salicylate, 30 per cent., showing marked œdema of the media producing separation of the muscle fibres as indicated by "A."

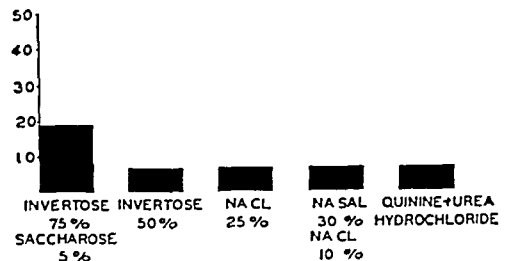
sclerosing substance showed some evidence of œdema. The œdema was most extensive forty-eight hours after the injection, at which time in 55 per cent. the œdema was

classed as + + + +, 30 per cent. as + + +, and 15 per cent. as + +. Phenol, 1 per cent., produced œdema in the greatest number of instances: i.e., in fifteen (93.7 per cent.) of sixteen observations. Mer-

— EDema
— MUSCLE HYPERTROPHY
— LEUCOCYTIC INFILTRATION
— CONNECTIVE TISSUE PROLIFERATION



GRAPH V.—Graphic representation of changes occurring in the wall of the vessel as a result of the intravenous injection of sclerosing agents.



HEMORRHAGE IN MEDIA

GRAPH VI.—Graphic representation of the percentages of observations in which hemorrhage in the media was produced by the intravenous injection of sclerosing substances.

curic iodide, 1 per cent., caused œdema in the fewest instances of all the substances investigated, it being present in thirteen (72.2 per cent.) of eighteen observations.

Changes in Muscle.—In twenty-four (6.8 per cent.) of the 348 veins, the muscle of the

media was either fully or partially destroyed. In twenty (5.7 per cent.), the destruction was complete, whereas in four (1.1 per cent.), it was partial. Four (25 per cent.) of the twenty instances of complete destruction of muscle occurred in veins injected with quinine and urea hydrochloride. Of the eighteen veins injected with this solution, complete or partial destruction of the muscle occurred in five (27.7 per cent.); in four (22.2 per cent.) there was complete destruction; and in one (5.5 per cent.) there was only partial destruction. Of seventeen veins injected with sodium salicylate, 30 per cent., and sodium chloride, 10 per cent., there were four (23.5 per cent.) instances of complete or partial destruction of the muscle. Of these three (17.6 per cent.) were complete and one (8.5 per cent.) was partial. Three (17.6 per cent.) of seventeen veins injected with sodium salicylate, 40 per cent., showed complete destruction of muscles. In a large number of observations, there was a suggestion of muscle hyperplasia. The finding was based upon an apparent extension of muscle fibres and bundles into the adventitia. (Fig. 6.) In 246 (70.7 per cent.) of 348 veins, there was definite evidence of muscle hypertrophy, as demonstrated by increase in the size of the muscle cells and

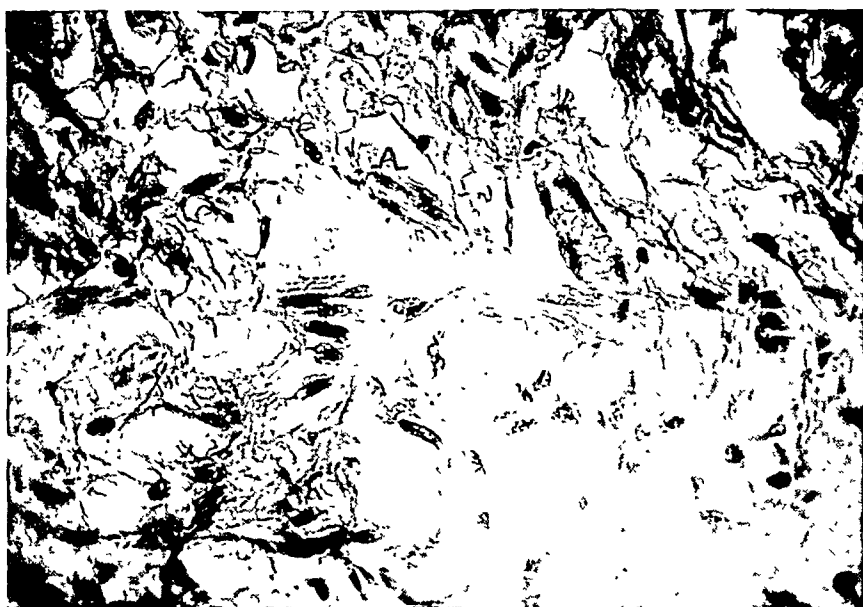


FIG. 6.—(VV-360.) High-power photomicrograph taken at junction of media and adventitia of vein injected ten days previously with invertose, 75 per cent., and saccharose, 5 per cent., showing extension of muscle bundles of media into adventitia as illustrated by "A."

bundles. (Graph V.) In the first one-half hour, hypertrophy occurred only once (5 per cent.) in twenty observations, whereas of the twenty observations made at the end of three hours, this was present in ten (50 per cent.). Seven (17.5 per cent.) of the forty observations made on or before the first hour, and 239 (77.6 per cent.) of the 308 observations made on or after the third hour showed muscle hypertrophy. The highest incidence of muscle hypertrophy occurred in veins injected with sodium salicylate, 30 per cent. (88.9 per cent.), and phenol, 1 per cent. (87.5 per cent.), invertose, 75 per cent. (83.3 per cent.) and dextrose, 66 per cent. (83.3 per cent.). The lowest incidence of muscle hypertrophy occurred in the veins injected with quinine and urethane, probably because of the extensive muscle destruction which resulted from the intravenous injection of this substance.

Leucocytic infiltration was demonstrated in thirty veins (8.6 per cent.). (Fig. 7.) Eighteen (63.4 per cent.) of the thirty veins were removed twelve and twenty-four hours after the injection. Of the forty veins extirpated twelve and twenty-four hours

INTRAVENOUS SCLEROSING INJECTIONS

after the injection with sclerosing agents, eighteen (45 per cent.) showed leucocytic infiltration. Of the 307 veins removed before the twelfth hour and after the twenty-

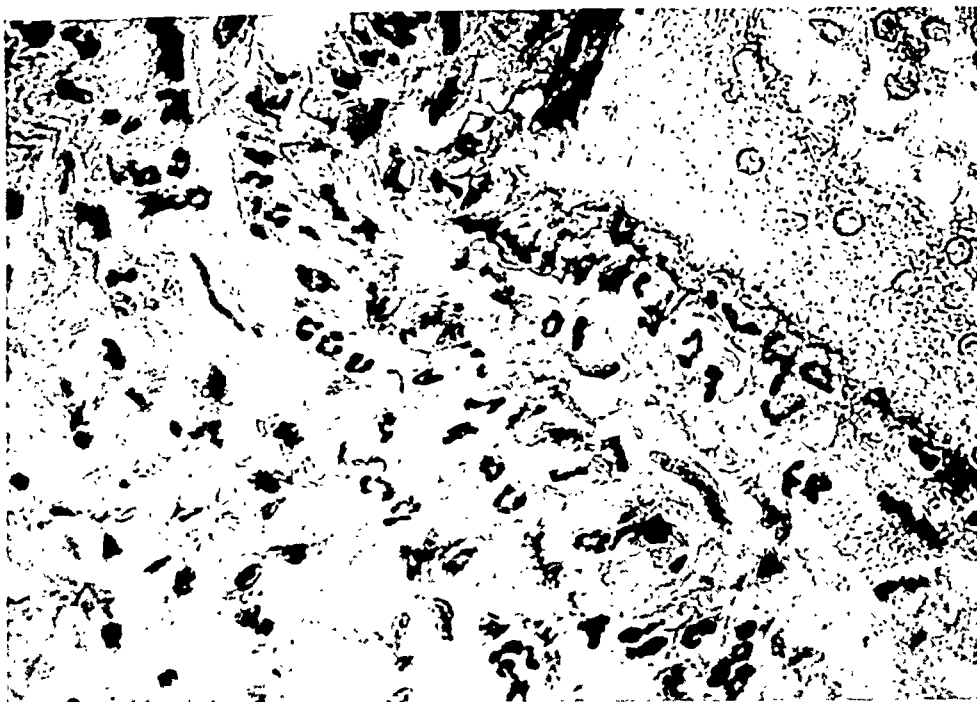


FIG. 7.—(VV-257.) High-power photomicrograph of vein injected twenty-four hours previously with dextrose, 66 per cent., showing leucocytic infiltration of the media.

fourth hour, only twelve (3.9 per cent.) had leucocytosis. (Graph V.) The leucocytic infiltration was greatest in those veins injected with quinine and urea hydrochloride.

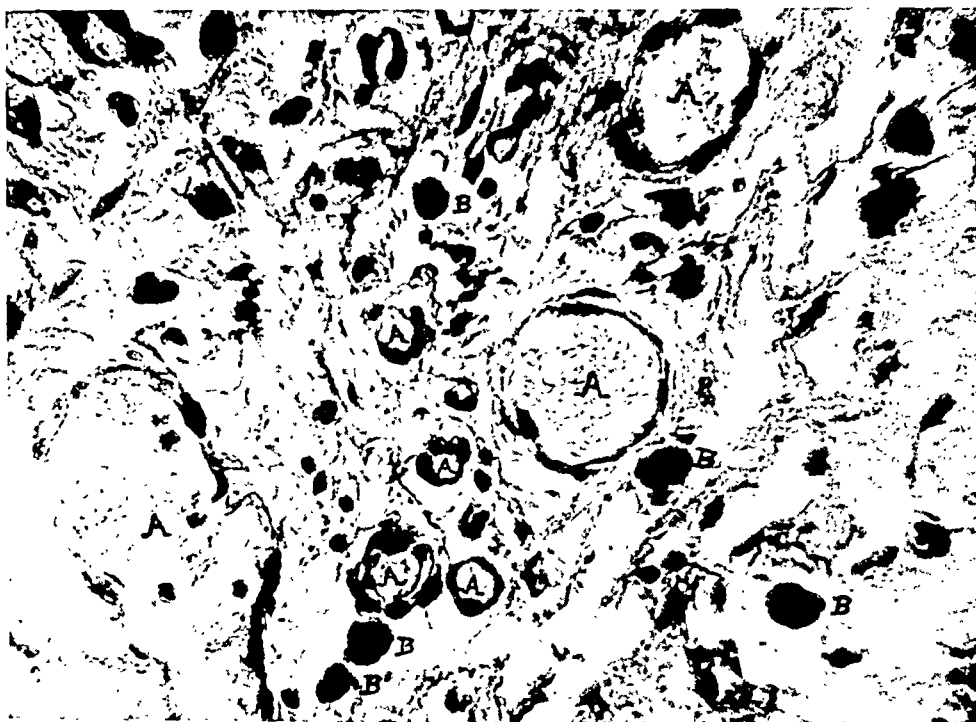


FIG. 8.—(VV-487.) High-power photomicrograph of thrombus in vein injected eight weeks previously with invertose, 75 per cent., showing recanalization of thrombus. Blood vessels indicated by "A" and phagocytosis of hemosiderin by endothelial cells by "B."

Five (27.7 per cent.) of the eighteen veins injected with this solution showed extensive leucocytosis. Seventeen and six-tenths per cent. of the veins injected with sodium

salicylate, 40 per cent., and sodium chloride, 20 per cent., showed a leucocytosis. Both mononuclear and polymorphonuclear cells were found in the exudate. There were also large numbers of endothelial cells. The number of polymorphonuclear leucocytes was never so great as that seen in bacterial inflammations. The endothelial cells showed evidence of phagocytosis and frequently were loaded with hemosiderin. (Fig. 8.)

In seven (2.01 per cent.) of the 348 veins, hæmorrhage was found in the media. (Fig. 9.) In two (28.5 per cent.) veins injected fourteen days previously, in three (42.8 per cent.) injected four days previously, and in one each injected twelve and twenty-four hours previously, there was hæmorrhagic infiltration of the media. (Graph VI.) Three (42.8 per cent.) of the veins with hæmorrhage had been previously injected with invertose, 75 per cent., and saccharose, 5 per cent. One vein each (14.2 per cent.) had been injected with invertose, 50 per cent.; sodium chloride, 25 per cent.; sodium salicylate, 30 per cent. and sodium chloride, 10 per cent.; and quinine and urea hydrochloride. In four (57.1 per cent.) of the seven veins in which hæmorrhage was observed, the substance used was invert sugar alone or combined with saccharose.

Fibrosis of the vein wall was frequently observed in the veins injected with sclerosing substances. Of 348 observations, in seven (2.1 per cent.) the wall of the



FIG. 9.

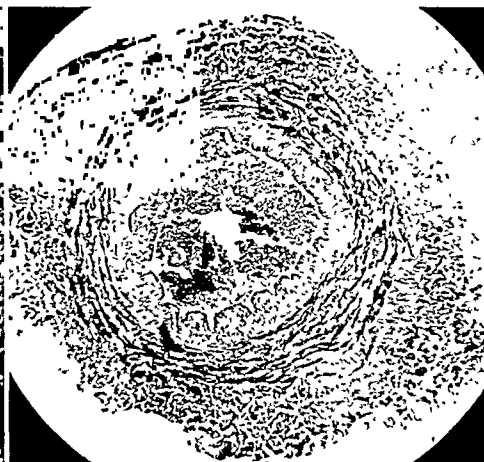


FIG. 10.

FIG. 9.—(VV-315.) High-power photomicrograph of media of vein injected four days previously with sodium chloride, 25 per cent., showing hæmorrhage causing wide separation of the muscle fibres of the media.

FIG. 10.—(VV-480.) Low-power photomicrograph (Mallory connective-tissue stain) of vein injected eight weeks previously with quinine and urea hydrochloride, showing fibrosis of the media with wide separation of the muscle bundles.

vein was so destroyed by the sclerosing substance that it could not be determined whether connective-tissue proliferation was present or not. Of the remaining 341, there was connective-tissue proliferation in 104 (30.5 per cent.). (Fig. 10.) There were only seven (3.5 per cent.) of the 200 veins injected within ten days and ninety-seven (67.5 per cent.) of the 148 veins injected fourteen or more days previously which showed evidence of connective-tissue proliferation. (Graph V.) Fibrosis of the media was found in all the veins injected four and six weeks previously. The greatest amount of fibrosis occurred in those veins (41.7 per cent.) which were injected with mercuric chloride, 1 per cent. In 41.1 per cent. of the veins injected with dextrose, 66 per cent.; invertose, 50 per cent. and sodium salicylate, 10 per cent., was there fibrosis. In 37.5 per cent. of the veins injected with quinine and urea hydrochloride and sodium salicylate, 40 per cent., fibrosis of the vein wall was observed. The earliest evidence of fibrosis was seen in a vein injected with sodium salicylate, 40 per cent.; three hours after the injection, there was noted a definite increase in the number of fibroblasts. Following the injection of invertose, 50 per cent., and sodium salicylate, 10 per cent., there was evi-

INTRAVENOUS SCLEROSING INJECTIONS

dence of connective-tissue proliferation as early as twelve hours and four days, respectively, after the injection. In those veins with thrombi, there occurred an early invasion of the thrombus with fibroblasts which progressed so that during the later periods (after eight weeks) it was frequently impossible to distinguish the vein wall from the thrombus. (Fig. 11.)

CHANGES IN THE ADVENTITIA

The most constant change observed in the adventitia following the intravenous injection of sclerosing substances was a dilatation of the vasa vasorum. In many instances, there was in addition to the dilatation evidence of new blood-vessel formation. Three hundred and seven (88.2 per cent.) of the 348 veins examined showed evidence of dilatation of the vasa vasorum. Ten (25 per cent.) of the forty observations made one-half hour and one hour, respectively, after the injection of the sclerosing substance, and 297 (96.4 per cent.) of the 308 observations made three hours or longer

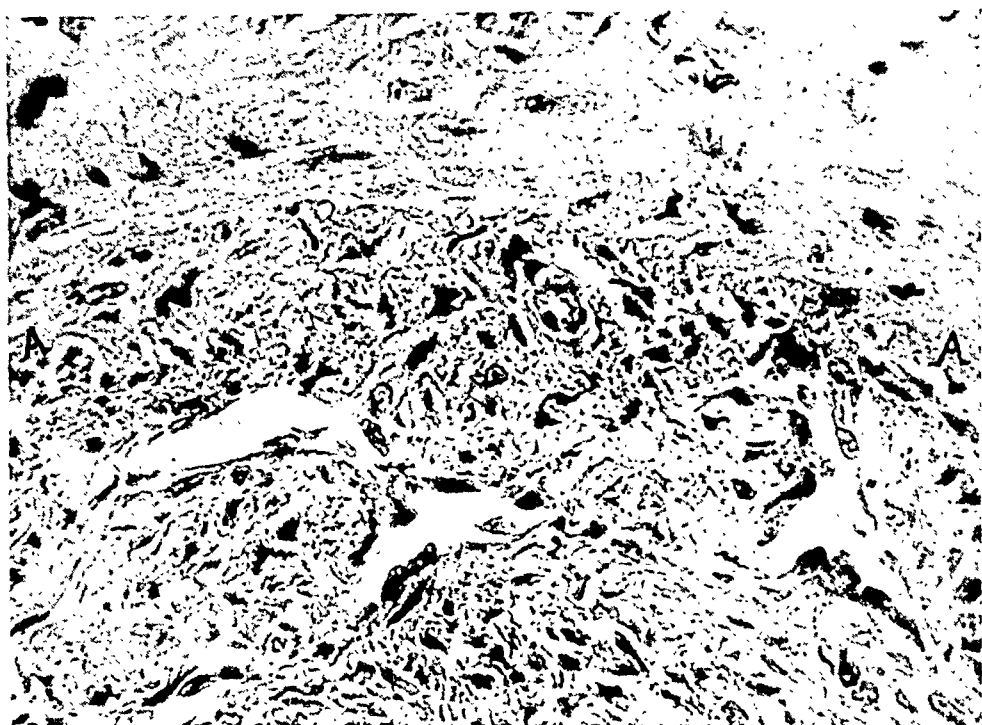
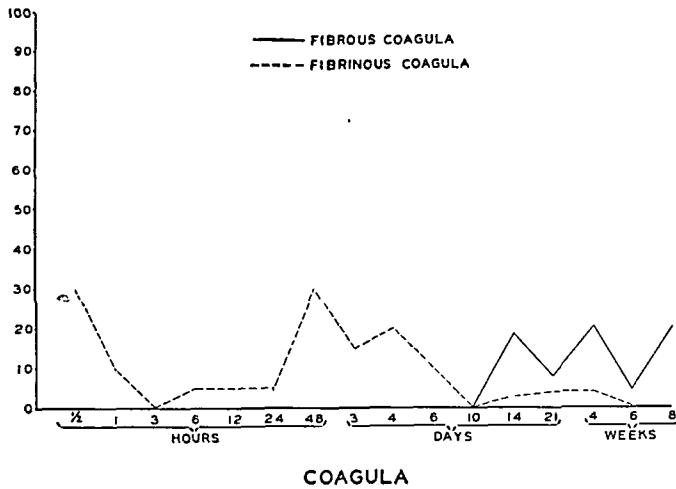


FIG. 11.—(VV-395.) High-power photomicrograph taken at junction between vein wall and organized thrombus in vein injected fourteen days previously with invertose, 75 per cent., and saccharose, 5 per cent., showing intimate attachment of thrombus to vein wall at "A."

after the injection of the sclerosing substance showed evidence of dilatation of the vasa vasorum in the adventitia. The most marked reaction as regards dilatation of the vasa vasorum was observed in those veins injected with sodium salicylate, 40 per cent., and invert sugar, 75 per cent. All the veins injected with these substances showed evidence of dilatation of the vasa vasorum.

Thrombi.—Thrombosis occurred in forty-six (13.2 per cent.) of the 348 veins examined. Of these, thirty-one (67.4 per cent.) were fibrinous and sixteen (34.8 per cent.) were fibrous. Fibrinous thrombi occurred in 8.9 per cent. of the 348 veins. The greatest number of fibrinous thromboses, as might be expected, occurred early after the injection of the sclerosing substances. Of the 181 veins examined on or after the sixth day, only five (2.9 per cent.) contained fibrinous thrombi. Of the thirty-one fibrinous thrombi, sixteen (51.6 per cent.) occurred in the sections removed on the second, third, and fourth days. These sixteen (20 per cent.) fibrinous thrombi occurred in eighty veins examined whereas only fifteen (5.2 per cent.) occurred in the remaining 268 veins. (Graph VII.) Those substances causing the greatest number of fibrinous

thrombi were sodium salicylate, 40 per cent., and mercuric chloride, 1 per cent. In both instances fibrinous thrombi developed in four (23.5 per cent.) of eighteen obser-



GRAPH VII.—Graphic representation of the percentages of observations made after the intravenous injection of sclerosing agents in which both fibrous and fibrinous thrombi were present.

vations. The thrombi developing in the veins injected with sodium salicylate, 40 per cent., were more extensive than those developing in the veins injected with mercuric chloride, 1 per cent. Organized thrombi were found in sixteen (4.59 per cent.) of the

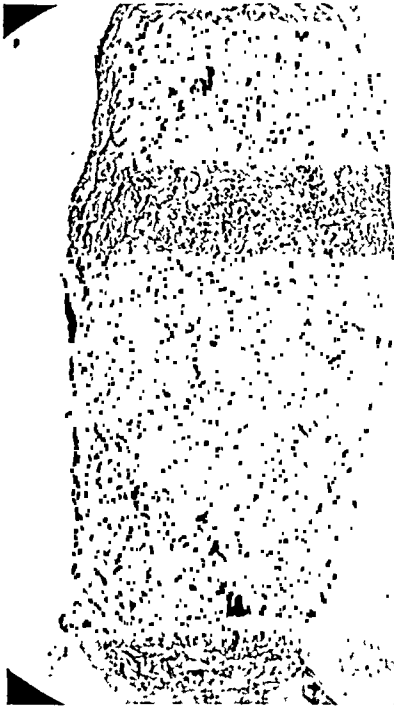


FIG. 12.



FIG. 13.

FIG. 12.—(VV-487.) Low-power photomicrograph of vein injected eight weeks previously with invertose, 75 per cent., showing complete obliteration of lumen of vessel by organized thrombus. There are a large number of new blood-vessels in the thrombus and considerable deposition of hemosiderin.

FIG. 13.—(VV-395.) Low-power photomicrograph of vein injected fourteen days previously with invertose, 75 per cent., and saccharose, 5 per cent., showing complete obliteration of vessel with organized thrombus. There are a large number of newly formed blood-vessels in the thrombus.

INTRAVENOUS SCLEROSING INJECTIONS

348 veins. (Graph VII.) (Fig. 12.) All were in veins removed fourteen days or longer after the injection. Eleven (16.7 per cent.) of the fibrous thrombi occurred in those veins removed between two and four weeks inclusive after the injection. (Fig. 13.) The largest number of fibrous thrombi was caused by sodium salicylate, 40 per cent. (23.5 per cent.) of the veins injected with this substance. (Fig. 14.) Quinine and urea hydrochloride, sodium salicylate, 30 per cent., and sodium chloride, 10 per cent., each produced fibrous thrombi in three (17.6 per cent.) of seventeen veins injected. (Graph VIII.)

Canalization of the fibrous thrombi occurred in seventeen (94.4 per cent.) of the fibrous thrombi. (Figs. 8 and 11.) Canalization of the thrombus occurred most frequently in veins (23.5 per cent.) injected with sodium salicylate, 40 per cent. Canalization occurred in 17.6 per cent. injected with sodium salicylate, 30 per cent. and sodium chloride, 10 per cent.; and mercuric chloride, 1 per cent.; and in 16.6 per cent. of the

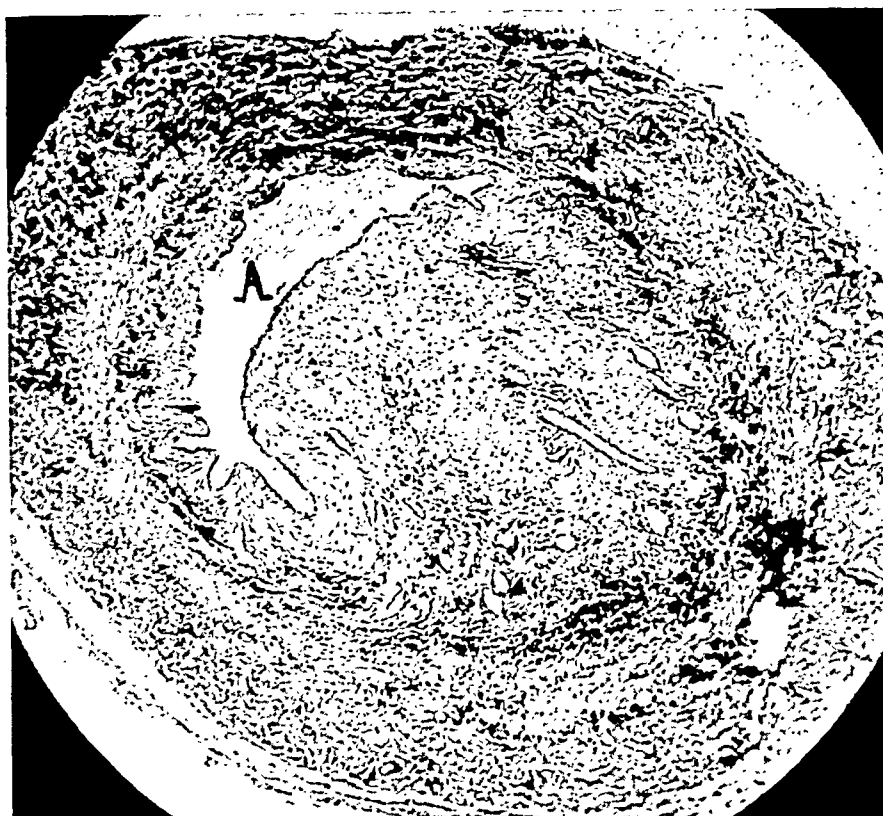
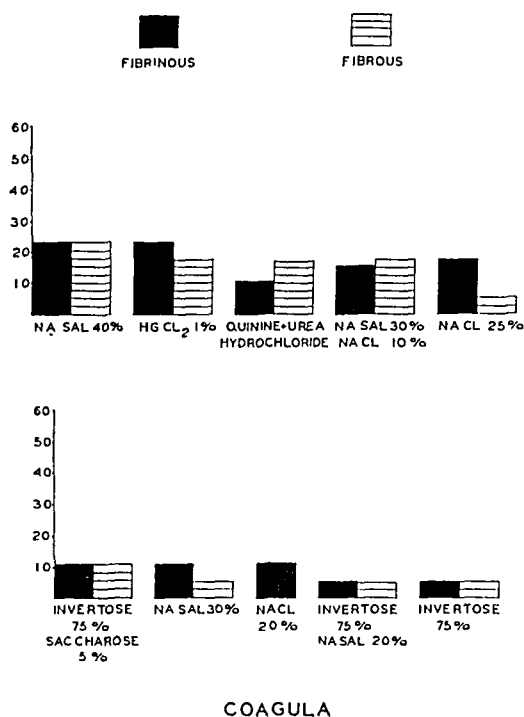


FIG. 14.—(VV-479.) Low-power photomicrograph of vein injected eight weeks previously with sodium salicylate, 40 per cent., showing almost complete obliteration of the lumen of the vein with organized thrombus. At the extreme left, as indicated by "A," is the original lumen of the vein.

veins injected with quinine and urea hydrochloride. There was no evidence of canalization on or before the tenth day, whereas all the cases in which canalization occurred were observed on or after the fourteenth day.

Comment.—As a result of intravenous injection of sclerosing agents, extensive changes occur in the wall of the vessel. The changes which occur in the vein wall may be considered as destructive and reparative. As might be expected, the endothelium is considerably altered. The results obtained by other investigators have not been consistent. Only partial destruction of the endothelium was observed twenty-four hours after the injection of sclerosing substances by Bazelis,⁷ Meisen,⁸ Hanschell,⁹ and Howard and his co-workers.¹⁰ On the other hand, Regard¹¹ and Schwartz¹² observed destruction of the endothelium within twenty-four hours, whereas Kern¹³ and

Wolf,¹⁴ whose examinations were made after forty-eight hours, report complete destruction of the endothelium. That the difference in the results obtained by these earlier investigators is due to the use of different solutions is possible, even though Meisen⁸ employed sodium salicylate, 40 per cent., as a sclerosing agent. This contention is substantiated by the results obtained in the present investigation in which it is found that the degree and extent of vascular change depend to a great extent upon the particular sclerosing agent employed. The extent and degree of endothelial destruction varied considerably according to the substance used. However, definite changes in the vein occurred within one-half hour after injection of the sclerosing substances; *i.e.*, 75 per cent. of the veins injected one-half hour



GRAPH VIII.—Graphic representation of the percentages of both fibrous and fibrinous thrombi produced by the respective sclerosing agents, arranged in order of their efficacy in the production of thrombi.

previously showed some evidence of endothelial destruction. (Chart I.) The incidence and extent of the endothelial destruction were classified as follows: seventy-five per cent. to complete destruction, 40 per cent.; 50 per cent. to 75 per cent., 10 per cent.; 25 per cent. to 50 per cent., 5 per cent.; and 0 to 25 per cent., 20 per cent. Veins injected one-half hour previously with sodium salicylate, 40 per cent.; sodium salicylate, 30 per cent. and sodium chloride, 10 per cent.; invert sugar, 75 per cent. and saccharose, 5 per cent.; and phenol, 1 per cent. showed complete destruction of the endothelium. Those veins injected with dextrose, 66 per cent.; sodium chloride, 20 per cent.; sodium salicylate, 30 per cent.; invert sugar, 50 per cent. and sodium salicylate, 10 per cent. had a destruction of the endothelium which

was classified as from 75 to 100 per cent. of the circumference of the vein. It is thus apparent that the more caustic solutions exert a destructive effect upon the vascular endothelium immediately or at least within one-half hour's time after the intravascular injection. The number of veins with endothelial destruction at the end of one-half hour was the same as those with endothelial destruction at the end of twenty-four hours, in each 75 per cent. Our results substantiate the findings of Wolf,¹⁴ that following the intravenous injection of mercuric chloride, the venous endothelium was only partially destroyed after twenty-four hours and completely destroyed after forty-eight hours. Endothelial destruction was incomplete until forty-eight hours and three days after the injection of mercuric chloride, 1 per cent., at which time it was estimated as 85 per cent. and 90 per cent., respectively. Hanschell⁹ was unable to determine any change in the endothelium of a vein injected fifteen minutes previously with quinine hydrochloride, 13 per cent., sodium salicylate, 20 per cent.; and sodium chloride, 20 per cent. Veins which we examined immediately after the intravenous injection of sodium salicylate, 30 per cent., quinine and urea hydrochloride, and dextrose, 66 per cent., solutions had 90 per cent., 100 per cent. and 100 per cent., respectively, of the endothelium destroyed. (Chart II.) The apparent discrepancy between our results and those obtained by Hanschell⁹ may be due to the fact that we employed more concentrated solutions, although the concentration of the quinine solutions were practically the same. A significant fact is that 71.2 per cent. of the observations made on or before the fourth day showed evidence of endothelial destruction, whereas only 16.7 per cent. of the observations made on or after the sixth day showed a similar destruction of the endothelium. This is undoubtedly due to the fact that between the fourth and sixth days a regeneration of the endothelium had occurred. This is in accord with the findings of Carrel and du Noüy,¹⁵ Howes¹⁶ and Harvey,¹⁷ *et al.* Carrel and du Noüy¹⁵ found that in the healing of wounds there was a latent period of from five to seven days before cicatrization occurred. Howes¹⁶ and Harvey¹⁷ found that in the healing of wounds in various tissues of the body there is a latent period of approximately four days before growth becomes appreciable. According to Regard,¹¹ defects in endothelium are rapidly replaced by a proliferation of the neighboring cells, and if proliferation is sufficiently rapid, the injured endothelium is covered with a "varnish" in order to prevent thrombosis. Binet and Verne¹⁸ observed that a marked endothelial hypertrophy occurred following the intravenous injection of sclerosing substances, so that the endothelium resembled undifferentiated mesenchyme. Bazelis⁷ found a marked proliferation of endothelium at the end of forty-eight hours, and Doerfell¹⁹ was of the opinion that the endothelial proliferation is of great importance as regards the anchoring of the thrombus. Endothelial proliferation was found in 12.9 per cent. of the veins examined in the present investigation. There was no evidence of it within the first six hours. Four and four-tenths per cent. of the veins examined on or before the fourth day and 22.1 per cent. of those examined

on or after the sixth day had endothelial proliferation. As mentioned above, 71.2 per cent. of the veins examined on or before the fourth day and 16.7 per cent. of the veins examined on or after the sixth day had endothelial destruction. It is evident that the percentages of endothelial destruction and endothelial proliferation are inversely proportional to one another.

Other changes occurring in the endothelium of vessels following the intravenous injection of sclerosing substances have not been stressed by previous investigators. These are undoubtedly significant even though of less importance than destruction of the endothelial cells. As has been mentioned previously, in 18.9 per cent. of all the veins examined, a portion of the endothelial cells was destroyed so that the nuclei were exposed to the lumen of the vessel. This differed from complete destruction of the endothelium in that the nuclei and parts of the cells were still adherent to the wall of the vein. It is possible that eventually in these veins a complete destruction of the endothelium might have occurred. Fifty-six per cent. of the veins in which this phenomenon was observed were removed on or before the twelfth hour, whereas 44 per cent. were removed on or after the twenty-fourth hour. Thirty-seven per cent. of the veins extirpated on or before the fourth hour showed evidence of "exposure" of the nuclei, whereas only 11.6 per cent. of those made after the twenty-fourth hour showed this phenomenon. Another change which was observed in the endothelial cells was vacuolization, which occurred in 43.4 per cent. of the entire group of veins. This change occurred relatively early after the injection, as it was found in 53.8 per cent. of the veins examined on or before the tenth day and in only 25.2 per cent. made after this time. That these changes in the endothelium and in the other layers of the vessel wall and not only endothelial destruction are responsible for the development of thrombi, is evidenced by the fact that the degree of endothelial destruction is not always proportionate to the incidence of thromboses. This will be discussed more in detail under the question of thromboses.

An inflammatory reaction to the chemical trauma, consisting of œdema and leucocytic infiltration of the media and dilatation of the vasa vasorum of the adventitia was frequently found. The occurrence of œdema in the wall of vessels injected with sclerosing substances has been emphasized by Regard,¹¹ Meisen,⁸ Schwartz and Ratschow,²⁰ and Lufkin and McPheeters.²¹ In the present investigation, œdema occurred in 83.3 per cent. of the veins examined. (Chart III.) Ninety-eight and two-tenths per cent. of the observations made on or before the third week after the injection, and 16.1 per cent. of those made on or after the fourth week showed evidence of œdema. In the present investigation, there was no parallelism between the degree of œdema, the extent of endothelial destruction, and the number of thrombi. Leucocytic infiltration of the vein wall has been observed by Wolf,¹⁴ Hanschell,⁹ Howard and his collaborators,¹⁰ Kern,¹³ Schwartz and Ratschow,²⁰ Meisen,⁸ and Lufkin and McPheeters.²¹ Meisen⁸ and Hanschell⁹ found evidence of leucocytic infiltration twenty-four

hours after the injection. Kern¹³ found that forty-eight hours after the injection of the sclerosing agent there was considerable inflammatory reaction which had completely disappeared at the end of a week. Schwartz and Ratschow²⁰ found that the inflammatory reaction had reached its height by the fourth day. Wolf¹⁴ observed a marked leucocytic infiltration five to seven days after the injection and Howard, *et al.*,¹⁰ stated that leucocytic infiltration was far advanced on the sixth day. In none of Lufkin's and McPheeters'²¹ cases was there any evidence of abscess formation; the leucocytes were largely scattered throughout the muscle fibres of the media. In the present investigation, leucocytic infiltration occurred in 8.6 per cent. of all the veins. Five and two-tenths per cent. of all (63.4 per cent. of those with leucocytosis) occurred in veins removed twelve and twenty-four hours after the injection. Forty-five per cent. of the veins removed twelve and twenty-four hours after the injection showed evidence of leucocytic infiltration and of all the other veins examined before and after these two periods, in only 3.9 per cent. was there leucocytic infiltration. Fifty per cent. of the observations made at the end of twelve hours showed evidence of leucocytosis but there was no leucocytic infiltration after the third day. Possibly the apparent discrepancy between our findings and those of Wolf,¹⁴ Howard, *et al.*,¹⁰ as regards the duration of leucocytic reaction may be due to the fact that our observations were made on normal veins, the contents of which were in normal motion whereas the observations of the other investigators were made in patients' varicose veins. Kern,¹³ in his experimental animals, found that there was considerable inflammatory reaction after forty-eight hours but that it completely subsided within a week.

A phenomenon observed in the present investigation but one which has been scarcely mentioned in the literature is hæmorrhagic infiltration of the vessel wall. Meisen⁸ mentions the occurrence of a perivascular hæmorrhagic œdema but does not refer to hæmorrhage in the vessel wall. Infiltration of the vessel wall with blood occurred in 2 per cent. of the veins examined in the present investigation. In 57.1 per cent. of the veins in which hæmorrhage was found, the injecting substance had been invert sugar either alone or combined with saccharose. No evidence of hæmorrhage was observed before the twelfth hour or after the fourteenth day. The greatest number occurred on the third day. Other evidences of inflammation found in the vessel wall were dilatation and an overfilling of the vasa vasorum, which occurred in 88.2 per cent. of all the veins examined. The highest incidence of the vasa vasorum dilatation was observed after the third hour and was most marked from then on up to the forty-eighth hour, although there was considerable dilatation of the vasa vasorum up to as long as eight weeks after the injection of the sclerosing agent. The finding of dilatation of the vasa vasorum has been emphasized by Meisen,⁸ and Howard, *et al.*¹⁰

In addition to the destructive and inflammatory changes occurring in the vein wall following the intravenous injection of sclerosing substances, repara-

tive phenomena are also present. These changes consist of primarily the production of fibrous tissue and changes in the musculature of the media. An end-result which occurs in the wall of the vein as a result of the chemical trauma and the inflammation which has not sufficiently been stressed by previous investigators is fibrosis of the vessel wall. Kern¹³ states that in his investigation he found the smooth muscle of the median coat of the vessel partially replaced by fibrous tissue. In the present investigation, fibrosis of the vessel wall, especially the media, but at times extending into the adventitia, was observed in 30.5 per cent. As might be expected, this was most marked in those observations made relatively late. Fifty-one and six-tenths per cent. of the observations made on or after the fourteenth day showed evidence of connective-tissue proliferation. It is probable that the fibrosis of the vessel wall is important as regards the ultimate results obtained by the injection treatment of varicosities in that contraction of the fibrous tissue tends to diminish the size of the lumen and strengthen the vessel wall. This is especially important in view of the fact that recanalization of the thrombus is especially likely to occur.

A phenomenon which we cannot find described by previous investigators but which was consistently found in a large number of the veins studied in this particular investigation is the reaction of the smooth muscle cells to the chemical trauma. This reaction consisted largely of a hypertrophy of the cells of the media as evidenced by an increase in their size. In 70.7 per cent. of the observations made there was evidence of muscle hypertrophy. It is possible that in some of the veins examined soon after the injection of the sclerosing agent the increase in the size of the muscle fibres which was interpreted as hypertrophy was in part due to an oedema, as oedema was found to be present in all the veins examined on or before the fourth day. Seventy-nine and five-tenths per cent. of the veins extirpated on or after the sixth hour showed evidence of muscle hypertrophy. In a relatively large number of instances, there was a suggestion of muscle hyperplasia, which was thought to be present because of apparent invasion of the adventitia by the smooth muscle cells and bundles of the media. It is commonly thought that regeneration of smooth muscle cells does not occur. According to Marchand,²² healing of an artery occurs by cicatrization without the individual elements of the vessels, especially the smooth musculature, taking part in the regeneration. Razzaboni²³ found that the regeneration of muscle in the vessel wall seldom occurs and then only to a slight degree. That newly formed smooth muscle cells can occur is shown by the investigation of Berry,²⁴ who was able to demonstrate that following injury to the human, guinea-pig and rabbit uteri, there occurred an increase in the number (hyperplasia) of smooth muscle cells. The authors agree with Berry²⁴ that, in wounds of smooth muscle, healing occurs largely by cicatrization but that even though the defect in the vessel may be largely closed by the production of scar tissue, in addition there occurs in the region of the wound an actual increase in the number of smooth muscle fibres. This contention is substantiated by the findings in the present investigation, although in no instance

was there evidence of mitosis observed in the smooth muscle cells. Maximow and Bloom²⁵ state: "Completely developed smooth muscle cells in the adult organism keep the ability to divide by mitosis to a certain degree—but this capacity for regeneration is small and as a rule great defects in smooth muscle tissue heal by scar formation. Whether smooth muscle cells in the adult organism may be formed from fibroblasts has not been established. It is practically certain that they may develop from the perivascular embryonic cells of the adult." The explanation for the muscle hypertrophy and the attempt at hyperplasia is probably that as a result of weakening of the vessel wall by the inflammatory reaction, an attempt is made on the part of the musculature to compensate for this by hypertrophy and possibly hyperplasia.

In the injection treatment of varicose veins, the desired result is obliteration of the vessel. This may be accomplished either through the medium of a thrombus or by producing agglutination of the two injured endothelial surfaces following their apposition. In the present investigation, no attempt was made to compress the vessels so that obliteration was secured only by the production of thrombi. Most of the previous investigators, Meisen,⁸ Wolf,¹⁴ Schwartz,¹² Hanschell,⁹ Howard, *et al.*,¹⁰ found that fibrinous thrombi occur within twenty-four hours after injection. Kern and Angle²⁶ did not make observations until after forty-eight hours, but then found fibrinous thrombi. Bazelis⁷ found no thrombi at the end of twenty-four and forty-eight hours following the intravenous administration of mercuric iodide, but observed fibrinous thrombi at the end of seventy-two hours. In the present investigation fibrinous thrombi occurred in 8.9 per cent. of all the veins examined. We were unable to corroborate Bazelis'⁷ observations as 30 per cent. of the veins examined by us one-half hour after the injection contained fibrinous thrombi. Fifty-one and six-tenths per cent. of all the veins with fibrinous thrombi were extirpated between the second and fourth days, inclusive, after the injection. The highest incidence of thrombi occurred in veins removed forty-eight hours after the injection. Of 121 observations made on or before the twenty-fourth hour, fibrinous thrombi occurred in 10 per cent., whereas of the twenty veins removed forty-eight hours after the injection fibrinous thrombi occurred in 35 per cent. Those substances which caused the greatest number of fibrinous thrombi were sodium salicylate, 40 per cent., and mercuric chloride, 1 per cent.

Only about one-half as many fibrous thrombi (4.59 per cent.) as fibrinous thrombi were observed. All occurred in veins removed fourteen days or longer after the injection. Sixty-eight per cent. of the organized thrombi occurred in veins removed between the second and fourth weeks. The largest number of fibrous thrombi was caused by sodium salicylate, 40 per cent.; quinine and urea hydrochloride; sodium salicylate, 30 per cent., and sodium chloride, 10 per cent. A relatively small number (13.2 per cent.) of thromboses occurred in the veins examined in the present investigation, as compared with those which occur in the varicose veins of patients injected with sclerosing agents. This is in all probability due to the fact that the veins

injected in the present series were normal, and that no stasis was present, which, as Aschoff¹ has shown, predisposes to thrombosis. The present results indicate that even extensive destruction of the endothelium need not be associated with thrombosis in the normal vein, although Aschoff states, "when, instead of slow retrogressive changes, the intima is suddenly stripped of its endothelial lining, then a reaction inevitably ensues, as occurs in all living tissues, accompanied by a pathological flow of lymph. Then it is indeed the alteration in the blood-stream in the region of the injured area which brings about a thrombosis by deposition."

The marked endothelial regeneration is probably partially responsible for the small number of thrombi. That thrombosis did not occur within the first four days after the injection before endothelial regeneration became marked may be due to a "varnishing" of the destroyed endothelium, as has been described by Regard.¹¹

All except one (94.4 per cent.) of the fibrous thrombi showed extensive evidence of recanalization. Canalization of the thrombus occurred most frequently in the veins injected with sodium salicylate, 40 per cent.; sodium salicylate, 30 per cent. and sodium chloride, 10 per cent.; mercuric chloride, 1 per cent.; and quinine and urea hydrochloride solutions. There was no evidence of recanalization on or before the tenth day, whereas all evidence of canalization occurred on or after the fourteenth day. Recanalization of the thrombosed vein may be responsible for the high incidence of recurrences reported by Howard, *et al.*¹⁰

As mentioned above and as has been previously stressed by deTakats and Quaint,²⁷ Kern,¹³ and Ochsner,²⁸ obliteration of a varicose vein may be secured with a minimum amount of thrombosis, by approximating (localized pressure over the injection portion) the injured endothelial surfaces and thus securing agglutination of the approximated surfaces. That venous occlusion secured in this way is preferable to that produced by a large thrombus is obvious, for the following reasons: First, a large thrombus becomes recanalized and may result in a recurrence. Second, any thrombus is a potential embolus. Both of these objections are more apparent than real, however. Even though recanalization does occur, the fibrosis in the vein wall tends to prevent subsequent venous dilatation. Then, too, not in all cases in which there is a return of symptoms is there a true recurrence, because in many there is involvement of other previously uninvolved veins.

As is shown by the firm anchoring of the thrombus to the vessel wall by its invasion by fibroblasts from the wall of the vein, there is little danger of a detachment. The inflammatory reaction which occurs infrequently (8.6 per cent. of cases) is almost entirely confined to the media and is of such a character that liquefaction of the thrombus as the result of the digestive action of tryptic ferments derived from leucocytes is not apt to occur.

Aside from the interesting and possibly valuable observations made concerning the effect of various sclerosing substances on the wall of veins, the present investigation is also probably of some value as regards the practical application of this form of therapy in the clinic. The desired result in the

INTRAVENOUS SCLEROSING INJECTIONS

treatment of varicose veins is obliteration of the varicosity by some means. Preferably, for reasons given above, this may be accomplished by compressing the vein and thus causing agglutination of the injured endothelial surfaces. Obliteration of the vein may also be accomplished by the production of a thrombus, which will subsequently become organized. In the present investigation following the intravenous injection of sclerosing agents, no attempt was made to determine what effect compression would have on the vein; the comparative results produced by the intravenous injection of various sclerosing substances must, therefore, be based upon the number of thrombi which developed. As shown in Table III, sodium salicylate, 40 per cent., produced the greatest number of thrombi (fibrinous and organized) as well as the most extensive endothelial destruction. It is thus evident that of the various sclerosing substances investigated, sodium salicylate, 40 per cent., is the most efficacious as regards the production of thrombi and probably would be the most efficacious in obliterating the vein if the vein were collapsed, because of its highest incidence of endothelial destruction. It is logical to assume that following destruction of the endothelium, approximation of the endothelial surfaces is apt to result in an agglutination of the two surfaces. From a practical standpoint, however, sodium salicylate, 40 per cent., has many objections in its clinical use, the principal ones being the severe cramp which it produces and the marked slough which occurs if a perivenous injection is made. Solutions of sodium salicylate, 30 per cent., and sodium chloride, 10 per cent., were also efficacious in producing organized thrombi, even though the number of combined thrombi and the amount of endothelial destruction were not great. The same objections to the clinical use of this solution may be offered as for sodium salicylate, 40 per cent. The next most efficacious agent in producing organized thrombi was mercuric chloride, 1 per cent., which also was the most efficacious agent in producing connective-tissue proliferation of the media. That mercuric chloride should not be used as a sclerosing agent is exemplified by the fatalities from mercurial poison which has resulted from the intravenous injection of this substance. Such cases have been reported by Hammer²⁹ and Mundt.³⁰ Quinine and urea hydrochloride solution was fourth in efficacy in producing organized thrombi and second in destructive action on the endothelium. Clinically, quinine and urea hydrochloride solution has many advantages. It can and should be used in small quantities and produces little or no pain. Also the danger of the development of necrosis if perivenous injection is made is much less than that obtained with the above-mentioned agents. Its use, however, is contra-indicated in patients with an idiosyncrasy to quinine and during pregnancy and menstruation. A solution of invert sugar, 75 per cent., and saccharose, 5 per cent., was fifth in efficiency in producing organized thrombi, whereas the next most efficient agent as regards development of organized thrombi was invert sugar, 75 per cent. The sugar solutions clinically have many advantages over the hypertonic salt solutions in that their injection is relatively painless. Invert sugar solutions, also, because of their lessened viscosity as compared with dextrose solutions, can be

injected relatively easily. The reaction which is produced is not so severe as that produced by the concentrated salicylate solutions and the danger of slough occurring if a perivenous injection is accidentally made is relatively slight. Sodium chloride, 25 per cent., followed invertose, 75 per cent., as regards the ability to produce organized thrombi. Sodium chloride solutions are, however, extremely irritating to the vein and their intravenous injection is extremely painful.

If one were justified in drawing conclusions from the results obtained in the present investigation which might be applicable to the treatment of patients with varicose veins, it seems permissible to suggest that because of the relatively high efficiency of the sugar solutions, especially invert sugar, 75 per cent., and invert sugar, 75 per cent. and saccharose, 5 per cent., in producing organized thrombi in normal veins of animals and because of the relatively few untoward symptoms which intravenous injection of these substances produces, these should be used in the routine treatment of patients with varicosities. If, however, the vein were small and there were no contra-indications to the use of quinine, quinine and urea hydrochloride would probably be more efficacious. In those instances in which one failed to obtain obliteration of the vein following the injection of the sugar solutions and quinine and urea hydrochloride, one would be justified in using the stronger concentration of salicylate solutions, especially sodium salicylate, 40 per cent. That this substance could not be used routinely is evident, because of the severe and painful reactions which it produces.

Additional investigations are being made, especially with the newer sclerosing agents that have been suggested.

SUMMARY AND CONCLUSIONS

(1) A comparative study of the effects of twenty different sclerosing substances on the veins of the dog is presented. In all, 348 histological examinations are made, extending from one-half hour to eight weeks after the injection.

(2) The changes in the vein wall consist of destructive, inflammatory and reparative changes.

(3) Endothelial destruction was observed in 45.1 per cent. of the veins. It was greatest in the veins examined on or before the fourth day. Regeneration of the endothelium occurred in a large number of instances between the fourth and sixth days. Other destructive changes in the endothelium were vacuolization and partial destruction of the endothelial cell.

(4) The inflammatory reaction consisted of œdema (83.7 per cent.), leucocytic infiltration (8.6 per cent.) and dilatation of the vasa vasorum (88.2 per cent.).

(5) The reparative changes consist of muscle hypertrophy (70.7 per cent.), fibrosis of the vessel wall (50.5 per cent.).

(6) Thrombi occurred in only 13.2 per cent. of all veins; of these, 67.4 per cent. were fibrinous and 34.8 per cent. were fibrous. Canalization of fibrous thrombi occurred in 94.4 per cent.

INTRAVENOUS SCLEROSING INJECTIONS

(7) Sodium salicylate, 40 per cent., produced greatest injury to the vein wall and the largest number of thrombi. Combining the results obtained in this investigation with clinical experience, it is felt that of the group of agents studied, invertose, 75 per cent., or invertose, 75 per cent. combined with saccharose, 5 per cent., should be used for routine clinical use. If these fail, quinine and urea hydrochloride and the higher concentration of sodium salicylate (40 per cent.) should be used.

BIBLIOGRAPHY

- ¹ Aschoff, Ludwig: Thrombosis, Lectures on Pathology. Paul B. Hoeber, New York, 1924.
- ² Magnus, G.: Zirkulationsverhältnisse in Varicen. *Deutsch. Ztschr. f. Chir.*, vol. clxii, p. 71, 1921.
- ³ McPheeters, H. O., and Rice, C. O.: Varicose Veins: The Circulation and Direction of the Venous Flow. *Surg., Gynec., and Obst.*, vol. xlix, p. 29, 1929.
- ⁴ Sicard, J. A., Forestier, J., and Gaugier, L.: Treatment of Varicose Ulcers. *Proc. Roy. Soc. Med.*, vol. xxi, p. 1837, Part I, 1928.
- ⁵ Ellenberger, W., and Baum, H.: Anatomie des Hundes. Paul Parey, Berlin, 1891.
- ⁶ Dalton, P. P.: Injection of Varicose Veins with Carbolic Acid. *British Med. Jour.*, vol. ii, p. 1037, 1928.
- ⁷ Bazelis, R.: Thesis de doct. Paris, 1924.
- ⁸ Meisen, V.: A Lecture on Injection Treatment of Varicose Veins and Their Sequelæ (Eczema and Ulcus Cruris), Clinically and Experimentally. *Acta Chir. Scand.*, vol. lx, p. 435, 1926.
- ⁹ Hanschell, H. M.: Notes on the Injection Treatment of Varicose Veins. *Brit. Med. Jour.*, vol. i, p. 542, 1928.
- ¹⁰ Howard, N. J., Jackson, C. R., and Mahon, E. J.: Recurrence of Varicose Veins Following Injection: A Study of the Pathological Nature of the Recurrence and a Critical Survey of the Injection Method. *Arch. Surg.*, vol. xxii, p. 355, 1931.
- ¹¹ Regard, G. L.: Treatment of Varicose Veins by Injections Inducing Sclerosis. *Rev. méd. de la Suisse Rom.*, vol. xlv, p. 102, 1925.
- ¹² Schwartz: Obliteration Treatment. *Arch. f. klin. Chir.*, vol. lvii, p. 733, 1929. (Ueber experimentelle und klinische Erfahrungen mit der künstlichen Verödung der Varicen.)
- ¹³ Kern, H. M.: Solution of Dextrose and Sodium Chloride for Obliterating Varicose Veins. *ANNALS OF SURGERY*, vol. xciii, p. 697, 1931.
- ¹⁴ Wolf, Ernst: *Med. Klin.*, vol. xvi, p. 806, 1920.
- ¹⁵ Carrel, Alexis, and du Noüy, P. L.: Cicatrization of Wounds. XI. Latent Period. *Jour. Exp. Med.*, vol. xxxiv, p. 339, 1921.
- ¹⁶ Howes, E. L., Sooy, J. W., and Harvey, S. C.: The Healing of Wounds as Determined by Their Tensile Strength. *Jour. Am. Med. Assn.*, vol. xcii, p. 42, 1929.
- ¹⁷ Harvey, S. C.: The Velocity of the Growth of Fibroblasts in the Healing Wound. *Arch. Surg.*, vol. xviii, p. 1227, 1929.
- ¹⁸ Binet, L., and Verne, J.: Fate of Vein After Obliteration. *Presse méd.*, vol. xxxiii, p. 761, 1925.
- ¹⁹ Doerffel, J.: Klinisches und experimentelles über Venenerödung mit Kochsalzlösung und Traubenzucker. *Deutsch. med. Wchnschr.*, vol. xxxiii, p. 901, 1927.
- ²⁰ Schwartz, E., and Ratschow, M.: Experimentelle und klinische Erfahrungen bei der künstlichen Verödung von Varicen. *Arch. f. klin. Chir.*, vol. clvi, p. 720, 1930.
- ²¹ Lufkin, N. H., and McPheeters, H. O.: Pathological Studies on Injected Varicose Veins. *Surg., Gynec., and Obst.*, vol. liv, p. 511, 1932.
- ²² Marchand: Prozess der Wundheilung, 1901; quoted by Goldzelber, M., and Makai, E.: Regeneration und Degeneration. *Ergeb. d. allgemein Path. u. path. Anatomie*, vol. xvi, p. 344, 1912.

- ²³ Razzaboni: Processo di guarigione delle lesioni traumatiche delle arterie, Bologna, 1910; quoted by Goldzelber, M., and Makai, E.
- ²⁴ Berry, F. B.: Regeneration of Smooth Muscle Cells. *Jour. Med. Research*, vol. xli, p. 365, 1920.
- ²⁵ Maximow, A. A., and Bloom, W.: *Text-book of Histology*. W. B. Saunders Company, Philadelphia, 1930.
- ²⁶ Kern, H. M., and Angle, L. W.: The Chemical Obliteration of Varicose Veins: A Clinical and Experimental Study. *Jour. Am. Med. Assn.*, vol. xciii, p. 595, 1929.
- ²⁷ de Takats, Geza, and Quint, H.: The Injection Treatment of Varicose Veins. *Surg., Gynec., and Obst.*, vol. I, p. 545, March, 1930.
- ²⁸ Ochsner, Alton: Chronic Cutaneous Ulceration of the Lower Extremities. *New Orleans Med. and Surg. Jour.*, vol. lxxxiv, p. 594, February, 1932.
- ²⁹ Hammer, F.: Tödliche Quecksilbervergiftung nach antivariköser Sublimatinjektion. *Deutsch. med. Wchnschr.*, vol. xlv, p. 45, 1919.
- ³⁰ Mundt, R. C.: Injection for Varicose Veins with Fatal Outcome. *Clin. Med. and Surg.*, vol. xxxvii, p. 361, 1930.

DISCUSSION.—DR. JOHN HOMANS (Boston) brought up the question as to whether or not a varicose vein is likely to be a source of thrombosis, as compared with one hitherto normal. Apparently embolism from varicose veins is rare, the reason being because their walls are diseased and the thrombus is more adherent than in normal veins. In any case, it seems to be true that the number of cases of embolism from thrombosis in hitherto normal veins is greater, at least relatively greater, than from varicose veins.

Is it not advisable to do more ligations of the femoral in Hunter's canal for local thrombophlebitis in the lower leg?

He recalled three cases of this disease. One died of embolism following an illness of several weeks. Another followed too violent massage; the patient was ill for a long time and finally recovered. The third case had frequent recurrences and seemed to be in danger of embolism, so Doctor Homans tied the femoral vein in Hunter's canal, for it seemed to him there was no way a clot could arrive at the lungs from the deep vessels of the calf except by way of the femoral veins. For in the veins communicating with those of the surface the current is from without inwards, the veins in any case are small, and so, if one ties the femoral vein, there will be no embolism. In the case treated by ligation recovery was rapid and satisfactory.

That brings up the question of whether the ligation itself may not be a source of trouble. He was quite sure that thrombosis in veins, whether normal or pathological, will almost always progress toward the heart until a strong current is reached, so that if one is to ligate a vessel to prevent the extension of clot, on the whole it is better to ligate near an entering branch. Doctor Matas had suggested that in connection with the ligation of arteries, but it is also true of the veins. One should ligate near but not too near an entering branch. He brought up this question, which is rather a fussy one, perhaps, as to where the ligation should be performed, because it may be true in some of these cases that the thrombosis is due to a factor, in any particular patient, of which we know nothing, and the thrombosis is likely to continue unless one takes pains to so conduct the operation that it will be the least likely to continue.

DR. HOWARD LILIENTHAL (New York City) remarked that he had for a long time been advising that in the cases of œsophageal injury with or without perforation, particularly on the right side, when the patient has fever and other signs of sepsis, especially when the blood gives a positive culture, the major axygos vein should be ligated and cut through a posterior mediastinotomy. One instance seen by him, a woman about thirty years old, had swallowed a fish bone. The characteristic signs of sepsis were present but this operation was refused.

INTRAVENOUS SCLEROSING INJECTIONS

One may find a view of the exposure as he has made it, as the colored frontispiece, in a book that he wrote in 1925 (Thoracic Surgery, W. B. Saunders).

DR. FRED B. LUND (Boston) had operated upon no thromboses of femoral veins, but in varicose veins he had seized upon the thromboses as the most favorable condition for ligating the saphenous and removing the varicosities. In the first place, the more extensive the thromboses, the more good one does. They are red and sore and will take weeks and weeks to absorb. Tie the vein above and remove them, without the usual bleeding that takes place when they are not thrombosed. It is not a major operation.

In the injection treatment of varicose veins one is trying to make a local clot. Here the patient is in bed with a large clot all the way down the leg. If it is stripped out, weeks and weeks of time are saved for him.

DR. ARNOLD SCHWYZER (St. Paul) said that one had only heard now of ligating those veins in cases of sepsis, but when, especially in a saphenous vein, the process has reached far up, that is a dangerous procedure because we do not know whether we are ligating too near the infectious part or maybe even below the infectious process (floating thrombus).

He remembered his first case of this kind, forty years ago. He was called to see a woman suffering from puerperal sepsis. She was six weeks after childbirth, with high temperature, both legs swollen, and redness over several areas of the right saphenous. Fifteen incisions were made, only incisions, to let the partly broken-down thrombi come out. The incisions were made all along the leg, as far as the very origin of the saphenous vein, but he didn't squeeze the parts to any extent. There was no bleeding, but if there should be bleeding here or there, so much the better.

In another case of puerperal sepsis things looked as though the woman was going to die; the temperature rose to 105° . They removed the septic uterus, but found on the right side a very thick cord running up toward the kidney region. They went extraperitoneally into this cord formed by the thrombosed ovarian vein, tore the infiltrated areolar tissue apart, opened the vein, and thus gave an outlet for the pus. The woman got well.

If the incision is away from the septic process, then the ligation, even quite a distance away, may be excellent. In one case of an apparently cryptogenetic sepsis, a man had temperatures of over 106° with daily chills of the most formidable type. They could not find anything except an uncertain little tenderness of the right side of the prostate. They finally went in and ligated the internal iliac vein, and the chills stopped. A week after this operation the chills reappeared. However, in the meantime, about a week after the operation, they could feel a slight bulging per rectum. Going in from the perineum some pus was found, and the patient got well without the left-sided ligation.

So, when one has a septic condition to deal with, azygos or saphenous or other, all one may have to do when one reaches the site of thrombosis is cut into the thrombosed vein for drainage.

DR. RUDOLPH MATAS (New Orleans) agreed thoroughly in principle with Doctor Stone's attitude in ligating and extirpating thrombosed inflamed veins whenever this was practicable. This is the best practice in hastening recovery and preventing secondary embolism. Unfortunately, this practice has decided limitations. One would not hesitate in dealing with the saphenous or the superficial veins but would hesitate and must halt when facing the femoral, iliac and other deep veins. Here the difficulty lies in determining the limit of the thrombophlebitic invasion. By the time the diagnosis is clearly established, one may be sure that the thrombus has extended into the iliac tracts far above the groin. Logically, the principle of preventive ligation and division of the iliac veins is even more indicated than in the superficial saphenous, for there the danger of fatal pulmonary embolism is much greater. The preventive ligation of the external

and internal iliacs and even the vena cava, as this has been carried out in a number of cases of progressive post-operative thrombosis and puerperal pelvic phlebitis, has not yielded encouraging results. Apart from the gravity of the intervention in the conditions under which it is performed, the uncertainty of reaching the limit of the thrombophlebitic process has deterred surgeons from adopting preventive ligations and excisions in the deep veins as a regular procedure.

Doctor Stone has done well to caution against overconfidence in the reputed benignity of the superficial saphenous thromboses. These are usually regarded as comparatively free from the risk of pulmonary embolism. While this is true of the majority of the cases there are too many exceptions to permit one to disregard the embolic risk.

In connection with Doctors Ochsner's and Garside's paper, he had recently had to lament a fatality from pulmonary embolism caused by the injection of less than one cubic centimetre of quinine urethane into a varix of the internal saphenous. The patient was a healthy, robust man of forty years and the varix stood out as a superficial coil which did not involve more than five inches of the vein. The injection had no immediate notable consequence, but within a week the patient developed an acute (afebrile) thrombophlebitis of the deep femoral veins with pain and great œdema of the whole limb. The injection evidently started a phlebitis which rapidly extended from the superficial to the deep veins by the communicating branches. The swelling was subsiding and the patient improving in general, when, at the end of the third week after he had developed the phlebitis, he died suddenly in a paroxysm of dyspnoea and precordial distress. He was reading a newspaper calmly when the embolus came and in little over a minute he was dead.

This is about the thirtieth embolic fatality following sclerosing injections for varicose veins that have been recorded in the literature. He was confident that the list could be much increased if the unreported cases were added.

Embolism and infarction may be regarded as exceptional occurrences when the number of the recorded fatalities is pitted against the hundreds of thousands of cases that are being injected all over the world with seeming impunity. But a single tragedy such as he related is sufficient to make one wary of all statements which proclaim the innocence and safety of the sclerosing intravenous injections.

Doctor Beer, in his admirable study of the azygos system, has opened a new chapter in regional phlebopathology and unveiled one of the most hidden recesses and least-frequented paths of the venous circulation in so far as the diagnostician and clinical pathologist are concerned.

In connection with the symptomatology of the azygos vein, Doctor Matas directed attention to a sign which is frequently observed in the physical examination of the chest and which he had interpreted as evidence of stasis or prolonged strain of the azygos system. This sign usually presents itself as a capillary venous ectasis in the form of a fine delicate network of dilated vessels which somewhat resemble a *nevus araneus* or a *caput medusæ* on a fine scale, spread as a narrow strip along the skin of the intercostal spaces on both sides of the chest. It appears usually along the line of the sixth, seventh, or eighth interspaces. The appearance of this network suggests that it is constituted by cutaneous radicals of the intercostal veins which become visible only when there is a persistent strain or obstructive stasis of the azygos or superior caval veins.

They appear in adults or individuals past middle age, more often in athletic individuals and working people who carry heavy burdens. Clinically, they always suggest some intrathoracic cause of interference with the upper caval and azygos circulation. These capillary ectases are so fine that they usually escape the observation of the patients themselves. These capillary networks must not be confused with the larger dilated varicose veins which develop as a compensatory collateral circulation in cases of permanent caval and portal obstructions. Their close relation to the diaphragmatic attachments has suggested the name "*Corona Phrenica*" by which it is known in his clinic.

THE DIFFERENTIATION OF SPASTIC FROM ORGANIC PERIPHERAL VASCULAR OCCLUSION BY THE SKIN- TEMPERATURE RESPONSE TO HIGH ENVIRON- MENTAL TEMPERATURE

BY FREDERICK A. COLLIER, M.D.

AND

WALTER G. MADDOCK, M.D. (by invitation)

OF ANN ARBOR MICH.

MANY studies carried on in recent years on peripheral vascular diseases have clarified the classification of these lesions and emphasized the importance of recognizing the type of vascular occlusion present. The recognition of the value of skin-temperature measurements has played an important part in furthering these studies.

One of the major functions of the skin is the dissipation of body heat. The temperature of the skin is a resultant of the heat brought to it by its blood supply and the loss of heat from its surface by radiation, conduction, convection and the vaporization of water. In normal subjects at light activity approximately 24 per cent. of the total heat dissipated is by the vaporization of water from the skin and lungs. External heat and cold modify the amount of blood supplied to the skin and thereby vary the skin temperature. This response of the organism to the environment is called the physical regulation of body temperature.¹

During the past two years we have studied the response of the skin temperature to changes in environmental temperature in normal individuals and in patients with peripheral vascular disease. The observations of the normal persons are recorded in Part I and those of patients with peripheral vascular disease in Part II.

PART I: NORMAL SUBJECTS

Procedure.—The study was carried on in a small room in which the temperature was kept fairly constant. A circulation of air was maintained by a small electric fan running at low speed. The points of skin temperature measurement were chosen with particular attention to the extremities and are shown in Fig. 1 with their identifying numbers. A "Tycos Dermatherm"² was used for all skin-temperature measurements. Thirty normal individuals between the ages of thirteen and sixty years were studied in order to establish the normal response. The subject, lying quietly on a stretcher and covered only with a perineal drape in the case of the men, and a perineal drape and a towel over the breasts in the case of the women, was exposed to the environmental conditions for one hour.* The skin temperatures at the various body points were recorded. The subject was then covered with a light rubber sheet† to the clavicular

* The one-hour period was selected because in that time the skin temperature reaches a reliable constancy of adjustment to a constant environmental condition.

† The rubber sheet was added to the blankets in order to better hold body heat and to raise more quickly the private environmental temperature. Air temperature beneath these coverings was found to range from 34.0° C. to 38.0° C.

line and wrapped up in three woolen blankets. (Fig. 2.) At the end of one hour skin-temperature measurements were again taken. The coverings were moved only sufficiently to apply the applicator to the skin so that the readings obtained would be as nearly as possible the skin temperatures as they existed under the coverings.

Data.—The response obtained from a representative group of six of the normal men and women is presented in Tables I and II. Columns A show the skin temperatures for the exposed period, columns B for the covered period. The averages of the skin temperatures at the various body points

are plotted as curves on Chart 1.

From an examination of the data for the exposed period, the following facts were elicited:

(1) The highest skin temperatures prevailed on the trunk, the lowest at the tips of the extremities, with greater differences occurring at lower environmental temperatures.

(2) A progressive lowering of the skin temperature of the extremities occurred from the proximal to the distal points measured. This gradient was more marked in the lower than in the upper extremities. In general, there was also a slight progressive lowering of the skin temperature from the tip of the first to the fifth digits.

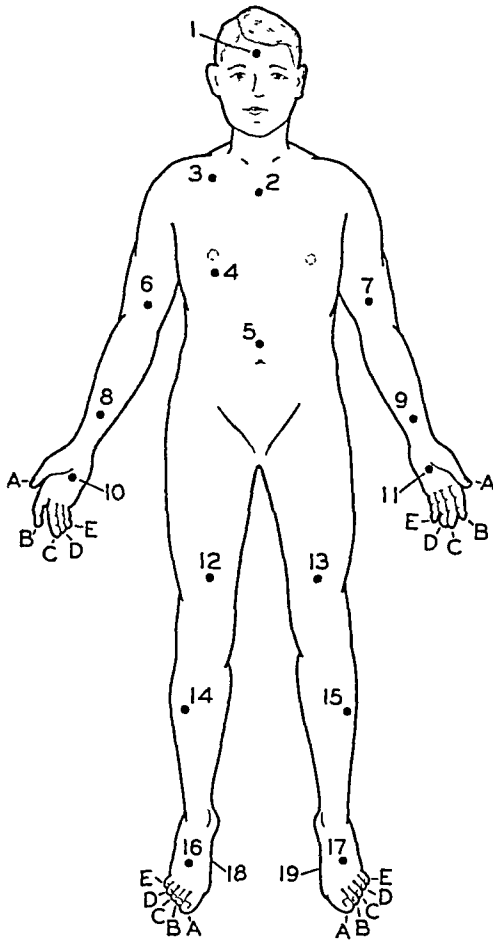
(3) In many instances under comparatively similar environmental conditions there was a fairly close approximation of the skin temperature of the same body point on different individuals. This fact is demonstrated by comparing subjects G. J. with E. S., A. B. with I. J., V. C. with E. G.

FIG. 1.—Points of skin-temperature measurement.

(4) Under essentially similar environmental conditions, differences occurring in the skin temperature of the same body point on different individuals were greater towards the tips of the extremities, and were more marked in the toes than in the fingers. Examples in comparing subjects J. G. with J. B., V. C. with E. G.

(5) Under similar environmental conditions the trunk points on men and women were approximately the same, while lower temperatures prevailed on the extremities of women than men. Example in comparing subject G. L. with A. K.

(6) No constant figure was found as a correction factor to correlate the differences in the skin temperature of individuals to different environmental temperatures.



SKIN-TEMPERATURE INDICATIONS

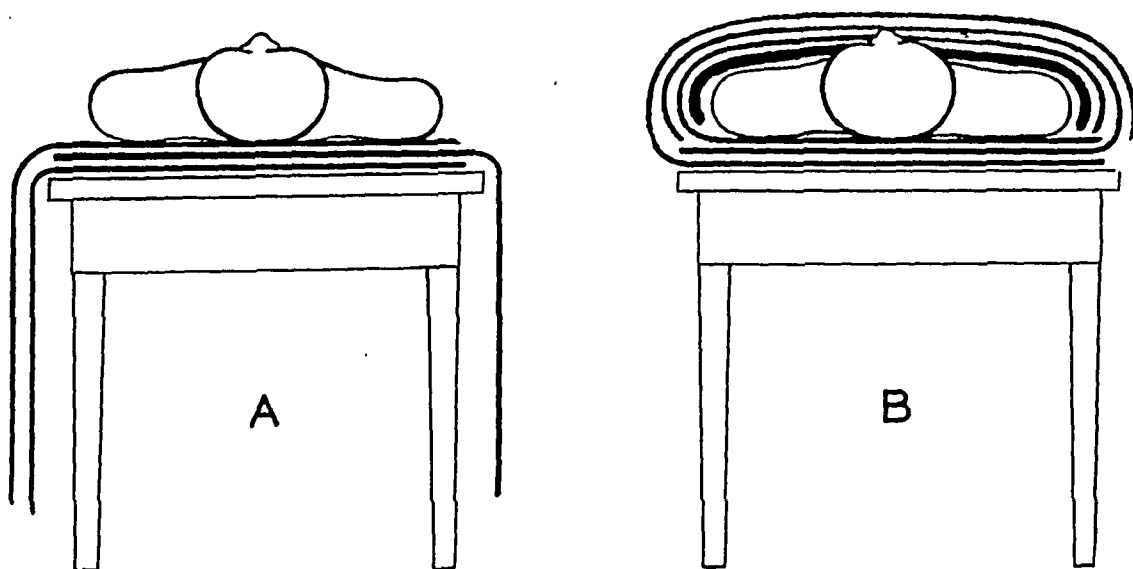


FIG. 2. (A)—Arrangement of blankets for exposure period. (B)—Arrangement of rubber sheet and blankets for covered period.

TABLE I

Data from Study of Six Normal Men

MEN													
SUBJECT, AGE.	J.B. 60	G.J. 33	G.L. 41	J.B. 15	N.M. 19	E.S. 18	AVERAGE						
DATE	3-24-31	3-23-31	3-4-31	4-15-31	4-9-31	4-9-31							
COLUMNS	A	B	A	B	A	B	A	B	A	B	A	B	
TIME	1050	1150	1000	1100	8:50	9:50	1025	1125	3:20	4:20	1025	1125	
ROOM TEMP. °C	24.0	24.0	25.5	24.0	24.0	24.0	24.5	24.0	27.0	27.5	25.5	26.0	25.0
MOUTH TEMP. °C	37.0	37.1	36.9	37.0	36.7	36.8	36.8	36.8	37.0	37.0	37.0	37.0	
BODY POINTS													
1	30.4	33.2	32.7	30.1	31.6	31.3	31.2	31.1	32.8	32.6	32.5	31.5	31.8
2	30.3	33.9	32.8	32.2	32.4	33.6	30.5	32.9	32.6	33.3	32.5	33.3	31.8
3	30.0	34.4	32.5	32.3	32.5	33.6	30.8	33.1	32.8	31.8	32.4	33.3	31.9
4	30.8	34.3	33.7	32.6	33.0	34.9	29.9	33.5	32.9	33.3	32.7	33.3	32.2
5	30.5	35.2	33.5	35.4	33.0	34.2	29.0	34.4	33.9	34.3	34.1	34.8	32.3
6	30.3	34.5	32.9	34.3	32.2	34.1	29.9	33.6	32.9	33.3	32.5	33.5	31.8
8	30.9	34.6	32.5	34.8	30.9	34.1	30.6	33.7	33.1	33.3	32.4	33.8	31.7
10	30.6	34.2	31.9	34.7	31.7	34.0	29.1	33.9	33.1	33.8	32.7	33.7	31.5
"a	29.5	34.4	31.5	34.9	31.8	34.2	29.6	33.0	33.1	33.5	32.2	32.8	31.3
"b	29.6	34.4	31.5	35.1	31.8	34.4	30.3	33.8	33.1	33.5	32.7	33.7	31.5
"c	29.8	34.8	31.5	35.1	31.5	34.5	30.7	33.8	32.9	33.5	32.0	33.5	31.4
"d	29.4	35.0	31.5	35.0	31.6	34.7	30.5	34.0	33.4	33.6	32.0	33.8	31.4
"e	28.9	35.3	30.1	35.2	31.4	34.6	30.3	33.0	32.5	33.6	31.9	34.1	30.8
7	31.5	35.3	33.5	35.0	32.5	33.8	30.2	33.8	33.1	33.8	33.2	34.3	32.3
9	31.0	35.5	33.2	35.5	32.0	34.3	29.4	33.9	33.8	34.1	33.2	34.5	32.1
11	31.4	35.6	32.6	35.7	32.4	34.3	29.0	34.2	33.4	34.6	33.4	34.8	32.0
"a	30.0	35.5	32.1	35.7	31.5	34.5	30.0	33.2	33.1	34.3	32.5	33.9	31.5
"b	29.8	35.3	32.0	35.8	32.4	34.7	29.6	33.4	32.8	33.6	32.5	34.1	31.5
"c	29.9	35.5	31.9	35.8	32.2	34.9	30.3	33.6	32.3	33.6	32.5	34.3	31.5
"d	29.4	35.6	31.7	35.8	31.6	34.8	30.3	34.4	32.3	33.8	32.5	34.3	31.3
"e	29.2	35.7	31.5	35.8	31.6	34.8	31.0	33.7	32.5	33.3	32.4	34.6	31.4
12	30.3	34.7	33.2	35.7	33.2	34.7	28.7	33.7	34.1	34.8	33.5	34.3	32.2
14	29.6	34.3	32.1	35.9	31.5	34.2	31.0	33.5	32.9	33.3	33.3	34.3	31.7
16	30.3	34.3	30.5	35.5	30.5	34.2	29.2	33.7	32.9	33.8	34.1	34.5	31.2
18	28.3	35.2	29.9	34.8	28.9	34.3	28.2	34.5	31.1	34.3	31.3	34.3	29.6
"a	28.6	35.4	29.5	34.7	25.8	34.4	28.2	33.4	31.9	33.6	28.2	34.3	28.4
"b	27.5	35.4	27.5	34.9	25.1	34.5	24.6	33.7	31.5	33.6	31.2	34.3	27.9
"c	27.0	35.4	27.7	35.2	24.5	34.5	24.8	33.7	30.6	34.1	27.5	34.5	27.0
"d	26.9	35.4	28.0	35.4	24.4	34.5	25.1	33.2	31.1	33.6	27.1	34.8	27.1
"e	26.9	35.4	28.5	35.3	25.0	34.5	25.9	33.4	30.9	32.8	27.2	34.5	27.4
13	30.2	34.6	30.5	35.8	32.3	34.5	29.0	34.4	33.8	34.3	32.9	34.6	31.5
15	30.0	34.6	32.0	35.1	30.8	34.4	27.3	34.1	33.2	34.3	34.1	35.1	31.2
17	29.7	34.8	30.5	35.2	29.4	34.9	29.3	34.1	32.4	34.3	32.4	35.3	30.6
19	29.0	34.4	29.7	34.1	28.9	34.5	28.0	35.2	31.3	33.8	31.2	35.3	29.7
"a	28.6	34.8	30.1	34.8	25.4	34.7	25.5	34.6	31.3	33.6	27.1	34.6	28.0
"b	27.8	35.0	29.5	34.8	25.2	34.9	24.0	34.1	30.7	33.3	26.5	34.6	27.3
"c	27.8	35.2	29.5	34.6	24.3	34.9	26.9	34.1	30.7	33.8	28.1	35.5	27.9
"d	27.6	35.0	29.5	34.6	25.0	34.9	25.8	34.0	30.7	33.3	28.2	35.3	27.8
"e	27.9	35.2	29.5	34.8	24.7	34.9	25.1	33.2	30.9	33.3	27.9	34.9	27.7

COLLER AND MADDOCK

Comment.—We will confine this discussion to the facts pertinent to the points we wish to emphasize in this paper. Benedict, Miles and Johnson, in 1919,³ demonstrated that on exposure of the body to moderate temperatures there prevailed higher skin temperatures on the trunk than on the extremities. Morton and Scott^{4, 5} consider this phenomenon to be due to vasoconstriction increasing peripherally and have applied to it the term

TABLE II
Data from Study of Six Normal Women

WOMEN													
SUBJECT	AGE	A. B.	23	I. J.	50	M. G.	38	A. K.	21	V. C.	17	E. G.	23
DATE		9-25-31		9-28-31		11-30-31		11-30-31		12-1-31		12-1-31	
COLUMNS		A	B	A	B	A	B	A	B	A	B	A	B
TIME		1100	1200	3:20	4:20	9:45	10:45	9:50	10:50	10:50	11:50	10:55	11:55
ROOM TEMP. °C.		23.0	24.0	23.0	23.0	24.6	24.0	24.6	24.0	27.0	27.1	27.0	27.0
MOUTH TEMP. °C.		37.0	37.0	36.9	37.0	37.1	37.0	37.3	37.0	37.1	37.4	37.2	37.5
BODY POINTS													
1		32.1	32.4	32.1	33.7	31.6	30.8	33.0	32.6	32.4	31.2	33.3	32.9
2		32.0	33.5	32.1	34.3	31.1	32.1	32.7	33.8	32.4	33.4	32.3	34.4
3		31.9	33.0	32.2	34.3	30.6	31.9	32.6	33.9	32.2	33.5	32.6	34.5
4		32.0	33.3	32.6	33.9	31.7	32.0	33.0	34.0	33.0	33.5	32.5	34.2
5		31.1	32.7	32.1	34.1	30.1	31.8	32.1	34.0	31.8	33.5	32.8	34.9
6		32.2	33.2	32.2	34.0	29.9	31.7	31.4	33.8	30.4	33.1	32.2	33.8
8		30.1	33.3	30.2	34.2	30.5	32.1	31.1	33.6	31.7	33.5	31.7	34.1
10		29.2	33.5	30.3	34.1	29.7	32.9	31.7	34.4	32.9	33.6	33.6	34.9
" a		26.5	33.1	28.8	33.7	28.0	32.6	30.8	33.7	32.0	32.7	32.1	34.2
" b		26.5	33.0	27.0	33.4	25.2	32.2	28.2	33.0	31.5	32.5	31.0	33.6
" c		26.2	33.0	26.0	33.2	24.3	32.0	27.6	33.4	31.7	32.5	30.8	34.0
" d		26.1	32.7	26.0	33.1	23.6	31.7	28.8	32.5	31.7	32.3	30.3	33.4
" e		25.5	32.3	25.5	33.0	23.2	31.5	29.1	32.4	31.9	32.2	30.3	33.0
7		30.5	33.5	31.7	33.7	29.6	31.9	31.2	33.6	31.7	33.6	31.2	34.0
9		29.8	33.6	31.7	34.3	31.8	32.6	31.2	34.4	31.8	33.8	33.0	34.8
11		28.8	33.3	30.8	33.9	31.2	33.4	30.6	34.7	33.8	33.5	34.1	35.3
" a		26.0	32.9	28.0	33.7	27.7	33.1	30.1	33.2	32.8	33.4	32.3	34.5
" b		26.1	32.7	26.7	33.5	25.0	32.0	30.1	32.6	32.7	33.3	32.0	34.2
" c		25.9	32.4	25.9	33.1	24.2	32.5	30.0	33.1	33.2	33.3	32.3	34.0
" d		25.1	31.4	25.5	32.5	23.8	32.4	30.2	32.9	33.2	33.1	32.4	34.0
" e		24.6	31.6	25.4	32.6	23.9	32.1	30.1	32.7	32.4	33.5	32.4	33.8
12		30.0	32.6	30.4	33.0	31.1	31.3	32.5	33.6	30.8	32.6	31.3	33.4
14		30.5	32.9	30.3	33.5	30.0	31.8	30.7	32.7	30.4	32.0	31.5	32.6
16		26.5	31.9	30.5	31.7	28.3	30.4	29.7	32.6	30.3	33.4	30.0	31.9
18		23.8	29.3	27.9	32.2	26.6	28.5	26.6	31.5	29.2	33.0	29.2	31.5
" a		23.3	28.4	24.9	33.2	23.6	28.7	24.0	32.4	28.3	33.0	25.3	31.2
" b		24.1	28.8	24.7	32.6	22.0	28.0	24.2	33.1	28.3	33.0	25.3	30.9
" c		23.5	28.0	24.8	32.2	23.0	27.1	23.4	32.0	28.0	33.1	25.7	30.5
" d		23.9	27.7	24.6	31.7	23.7	26.9	23.3	31.6	27.8	33.4	25.9	31.3
" e		24.8	27.2	24.4	31.7	24.0	26.6	22.9	31.1	28.0	33.1	26.1	31.1
13		30.6	32.7	29.4	32.5	30.6	31.5	31.9	33.6	30.3	33.3	30.9	33.0
15		27.5	33.3	29.6	33.4	29.8	31.5	30.7	32.1	30.8	32.6	31.3	32.9
17		26.8	30.7	29.4	33.1	29.1	30.6	29.7	32.2	29.7	33.2	29.4	33.1
19		23.9	29.5	26.4	32.5	27.1	28.7	26.5	32.2	29.0	33.0	27.5	31.7
" a		22.9	29.7	25.0	32.0	23.5	30.0	23.5	31.5	27.1	32.9	25.7	30.9
" b		24.0	30.4	24.7	32.7	22.0	29.0	24.2	32.6	27.2	33.0	24.9	31.6
" c		23.8	29.1	24.2	32.7	22.4	28.2	24.1	31.8	27.0	33.0	25.4	30.9
" d		24.1	28.7	24.1	32.6	22.7	27.0	24.0	32.7	27.1	33.0	26.2	31.9
" e		24.1	28.2	24.7	32.7	22.1	26.2	23.6	32.2	27.1	33.0	25.2	31.6

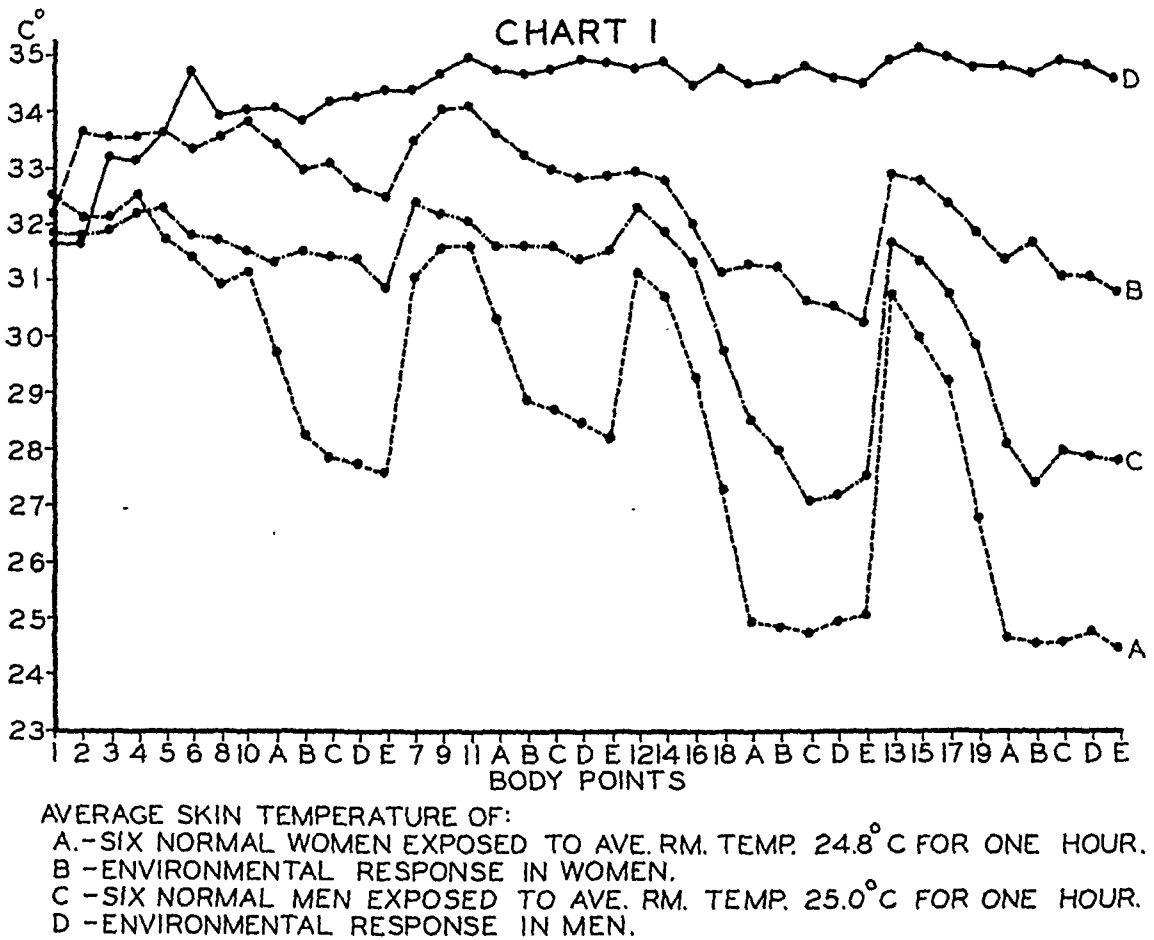
"vasoconstrictor gradient." Variations in the gradient were most evident at the tips of the fingers and toes. We consider measurements of the skin temperature at these points to be particularly informative of changes of vasomotor tonus. Under well-controlled conditions the measurement of the amplitude of such variations can be used to record stimulation or depression of the sympathetic nervous system.⁶

Since lower peripheral skin temperatures were found on women than on men it was evident that the peripheral vasoconstrictor gradient was more marked in the women. Benedict and Root⁷ observed this same phenomenon

SKIN-TEMPERATURE INDICATIONS

and suggested that the difference between the sexes might be due to the fact that women ordinarily wear lighter clothing on the extremities.

With the object of expressing the skin-temperature measurements of their studies at a constant environmental temperature Morton and Scott^{8, 9} adopted the correction figure of 0.3°C ., as presented by Vincent,¹⁰ to be added or subtracted for each degree of variation of the room temperature below or above 20.0°C . Vincent's constant was founded on the basis of 360 observations on the back of his own hand. Important objections to



Vincent's work have been made with criticisms based on the choice of the site for the point of investigation, on the method of measuring the skin temperature, and finally on the lack of consideration of the clothing. Cobet¹² concluded that the general applicability of Vincent's formula could not be accepted.

Reichenbach and Heymann,¹¹ in their work on the possible correlation between skin temperature and air temperature, developed a formula expressing the relation of the skin temperature of a dead body with a constant source of inner heat, to the temperature of the surrounding air. Their simplified formula corresponded fundamentally to the formula of Vincent. It was realized at the time of the development of the formula that on applying it to the living body the skin circulation was a local variable factor not

taken into consideration, as was also a possible variation in conduction from the inner temperature. To avoid these two factors as much as possible, Reichenbach and Heymann chose the forehead for the point of their investigation. Our data show that the skin temperature of the hands and feet presents the greatest magnitude of variations of all skin temperatures of the body, undoubtedly due to frequent variations in vasomotor tonus. Therefore, the hands and feet with the sympathetic nervous system control intact would be the worst possible location to expect to apply a constant figure for a correlation of skin temperature with environmental temperature.

The data from the covered period, recorded in columns B in Tables I and II and the average in Chart 1, showed:

(1) The skin-temperature measurements for the men were approximately the same on the trunk and the extremities, generally above 33.0°C . and more commonly between 34.0°C . and 35.0°C . Rather marked sweating occurred on most of the subjects.

(2) The response in women varied somewhat from that in men. The skin temperature of the well-covered trunk points of the women closely approximated the 33.0°C . to 34.0°C . of the trunk points on the men. The skin temperature of the upper extremities of women were slightly lower than those of the men, the average, however, being above 32.0°C . For the lower extremities the difference between the sexes was more marked, the average for the women being above 30.0°C . Excepting* the female subjects A. B. and M. G., the level of the whole average response for women would be above 32.0°C .

Comment.—Benedict,¹³ in 1925, demonstrated the high uniform skin temperatures prevailing after a night in bed with adequate bed clothing. We have produced the same result in a shorter period of time, probably considerably aided by the rubber sheet.

Several investigators^{14, 15, 16, 17, 18, 19, 20, 21, 22} have shown that in normal individuals the release of peripheral vasoconstriction by paralysis of the sympathetic nervous system with local or general anæsthesia results in skin temperatures about 33.0°C . or above in the area involved. Morton and Scott¹⁸ consider this temperature to be the low limit of the normal level when all vasoconstriction is removed and have applied to it the term "normal vasodilatation level." Brown²² previously showed that with an induced fever high uniform skin temperatures prevailed. It is evident that approximately the same skin temperatures were reached in our normal subjects in

* In the series of fifteen women studied, five showed definitely lower peripheral skin temperatures at the end of the covered period than the remainder of the group. These five stated that their feet were usually cold after a whole night in bed well covered. Their peripheral pulses were normal to examination. The inclusion of two of these subjects, A. B. and M. G., in the data presented reduced the low level of the foot points from 32.0°C . to 30.0°C .

SKIN-TEMPERATURE INDICATIONS

response to the environmental conditions of the covered period.* This result is in accordance with the factors of the physical regulation of body temperature. At high environmental temperatures the maximum amount of blood is brought to the surface of the body for the dissipation of heat.

A comparison of the data of the exposed period with the covered period showed:

(1) The number of degree rise in the skin temperature from the exposed to the covered period was approximately the same for both sexes. The level in both instances, however, was lower for the women.

(2) With the increase in the environmental temperature of about 10°C . the skin temperature of the trunk points increased only 1.0°C . to 1.5°C ., the upper extremity increased 2.0°C . to 5.0°C ., the lower extremity increased 2.0°C . to 7.0°C . The greatest changes took place in the hands and the feet.

Comment.—As already stated, the skin plays a very important part in the dissipation of body heat. About 65 per cent. of the total skin surface is on the extremities.²³ The greater response of the extremities to the increased environmental temperature suggests that the extremities, thrust out into the environment from the more vital trunk and head, play a greater regulating part in the dissipation of heat than the ratio of their surface area to the total. The control of this dissipation of heat from the extremities is probably one of the main functions of the “vasoconstrictor gradient.” This important part played by the extremities in the regulation of body temperature is not generally recognized.

From the study of the environmental response of the normal individuals we wish to emphasize the fact that with the high temperatures prevailing under the covers high uniform skin temperatures were obtained which were approximately at the “normal vasodilatation level.”

PART II: PERIPHERAL VASCULAR OCCLUSIONS

Having established the physiological response in normal individuals to the environmental conditions presented, the procedure was carried out in a similar manner on a number of individuals with symptoms of peripheral vascular occlusion. This application was made on the theoretical grounds that with the high environmental temperature under the coverings the physical regulation of body temperature would result in a maximal dilatation of the peripheral blood-vessels, and that the failure of the skin temperature to reach the “normal vasodilatation level” would be due to organic vascular occlusion. Morton's and Scott's¹⁸ term of “occlusion or obstruction index” was used to indicate the degree of failure of the skin temperature to reach the normal level.

In studying the environmental response in conditions of disease the following points were especially considered:

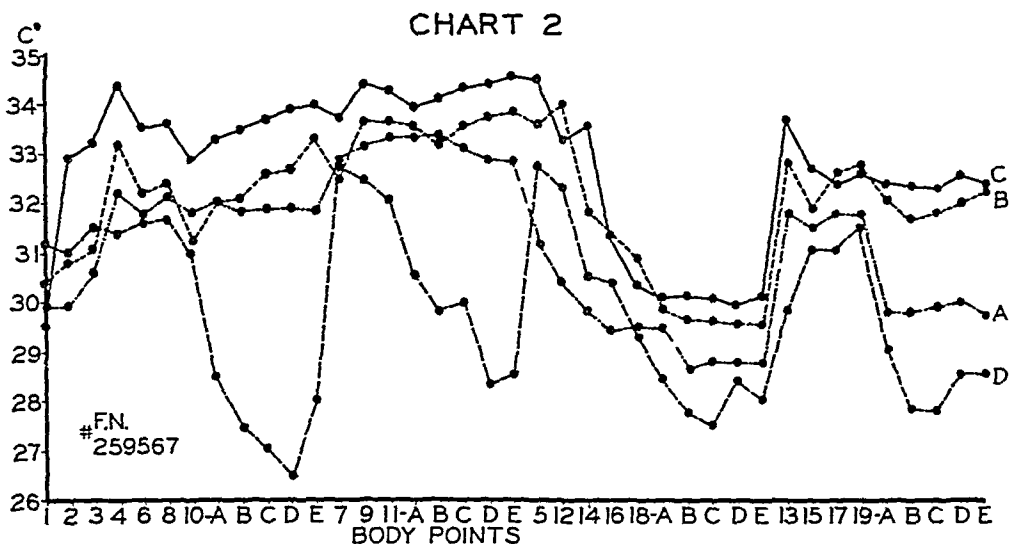
* See footnote † on page 719.

(1) The value of the procedure in differentiating spastic from organic peripheral vascular occlusion.

(2) A comparison of the result of this test with other differential tests.

(3) A comparison of the skin temperatures obtained with the test with those following sympathectomy.

In Chart 2 are shown the results of skin-temperature studies on a senile man, aged sixty years, who complained of pain in the right foot and who had a small area of gangrene about the right great toenail. The environmental response B showed a failure of the skin temperature of the right foot to reach the normal level of 33.0°C . and an occlusion index of about 3.5.



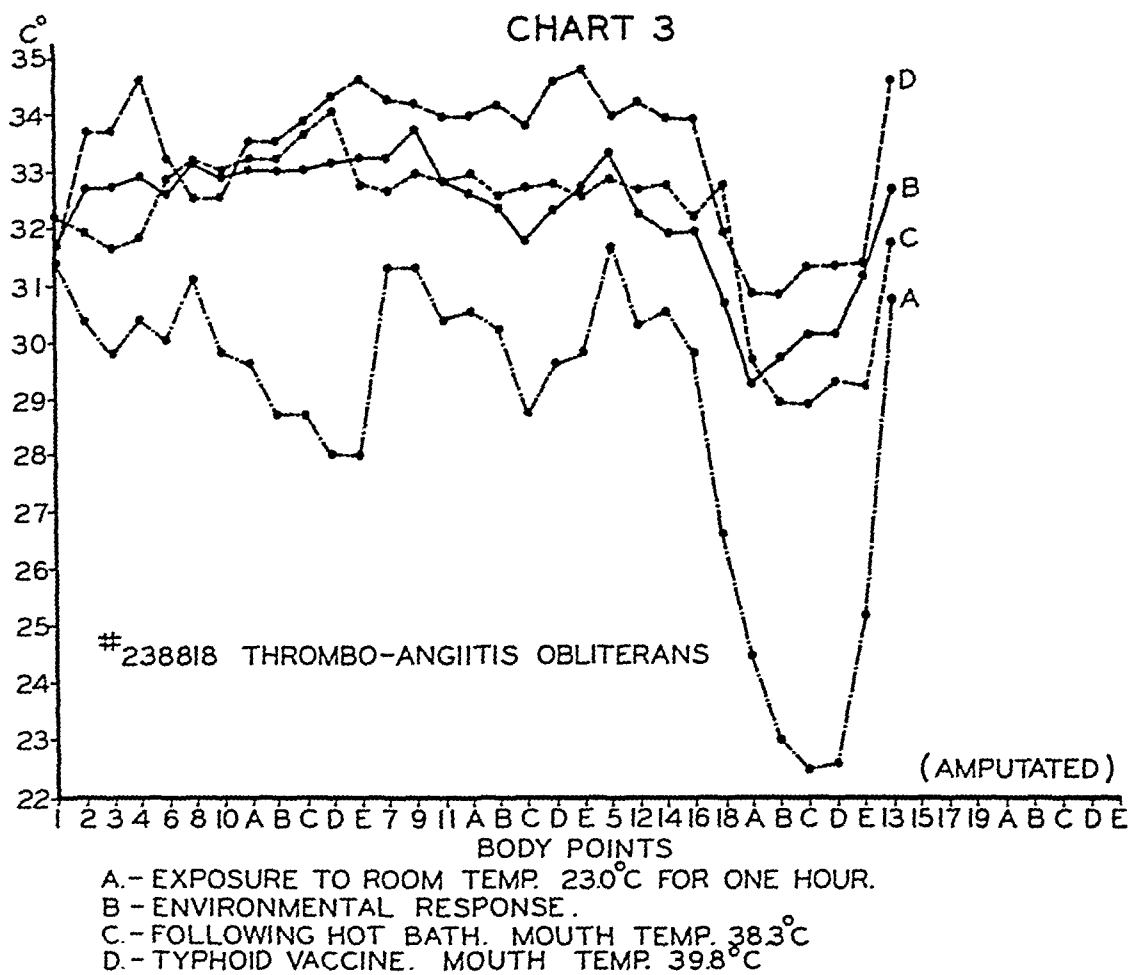
AGE 59 GENERALIZED ARTERIO-SCLEROSIS GANGRENOUS AREA ABOUT RIGHT GREAT TOENAIL.

- A. - EXPOSURE TO ROOM TEMP 25.0°C FOR ONE HOUR.
- B. - ENVIRONMENTAL RESPONSE
- C. - TYPHOID VACCINE. MOUTH TEMP 39.1°C
- D. - SPINAL ANESTHETIC

The skin temperatures of the left foot were nearly up to the normal level. A comparison for the right foot of curve B with the exposure temperature curve A showed a difference of about 1.0°C ., indicating a negligible degree of vasoconstriction present. There was an extremely close correspondence of the environmental test with the skin temperatures following typhoid vaccine indicated by curve C. With spinal anaesthesia the skin temperatures were generally lower, the levels for both feet were approximately the same, showing, according to this test, the same degree of circulation. With the environmental response, with typhoid vaccine and clinically, the circulation of the left foot was definitely better than that of the right. The markedly lower skin temperature of the hands, after the spinal anaesthetic, was probably largely due to the psychic trauma associated with the administration of this anaesthetic. The results of the tests clearly showed that marked organic vascular occlusion was present in the right leg.

SKIN-TEMPERATURE INDICATIONS

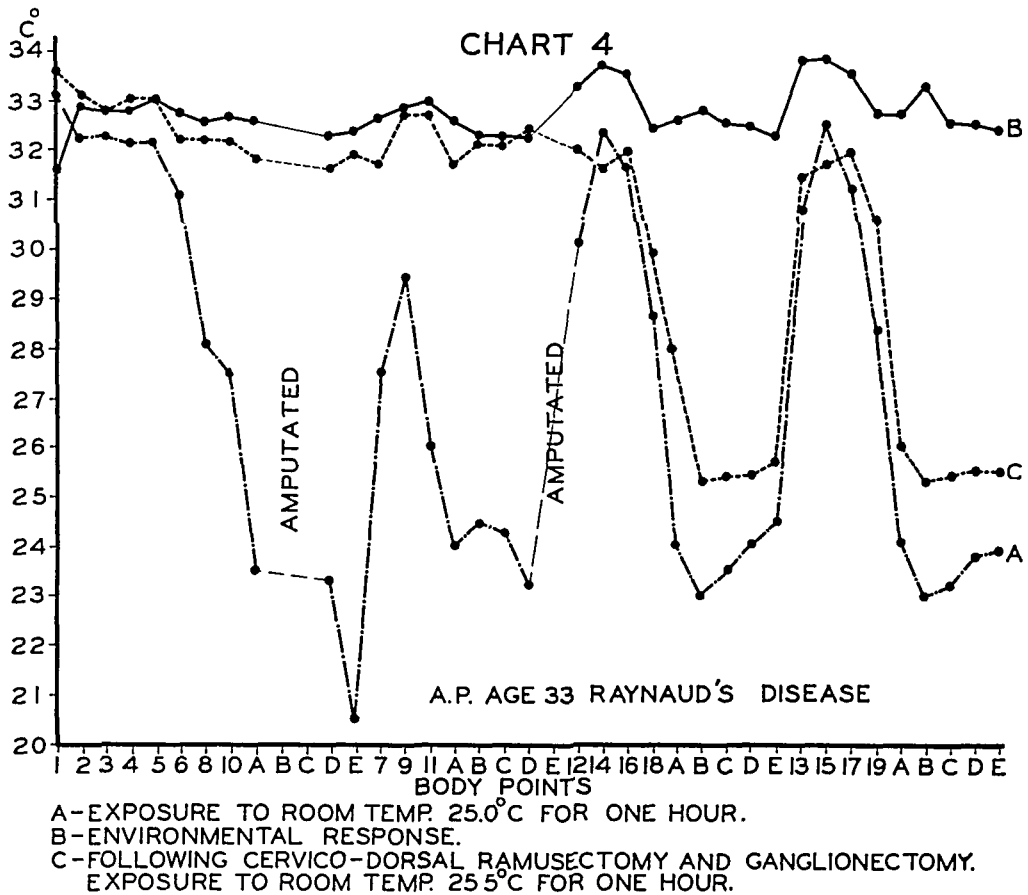
Chart 3 presents the result of skin-temperature studies on a male patient aged thirty-five years with thrombo-angiitis obliterans who complained chiefly of pain in the right forefoot. A left low thigh amputation had been done for extensive gangrene of the left foot. The rise in the skin temperature of the right foot from curve A to curve B indicated the production of a considerable degree of vasodilatation as the result of the environmental test. That definite organic occlusion was present was shown by the failure of the skin temperature of the right foot to reach 33.0°C ., the occlusion index being approximately 2.5. The result obtained with the environmental test compared favorably with the result of the other tests shown in curves C and



D. Some vasoconstriction superimposed on a marked organic occlusion made the wisdom of a lumbar sympathectomy doubtful. However, this was carried out and gave the result prognosticated by the tests.

In Chart 4 the application of the environmental test to a typical case of Raynaud's disease involving the hands showed in the rise from curve A to B the release of a rather marked degree of peripheral vasoconstriction. Curve B is approximately at the normal level, demonstrating the presence of little or no organic occlusion. Following a cervico-dorsal ramusectomy and ganglionectomy, skin temperatures, as shown in curve C for the affected area, closely approximated the prediction of the test.

Chart 5 presents the application of the environmental response in a girl aged nine years with a peripheral vascular disturbance associated with paralysis of the left leg from an old anterior poliomyelitis. The entire absence of organic vascular occlusion is shown by the level of the skin temperatures in the environmental response reaching the normal in curve B. Following a left lumbar sympathetic ganglionectomy the skin temperature of the left foot, as shown in curve C, closely approximated the level of the environmental response.

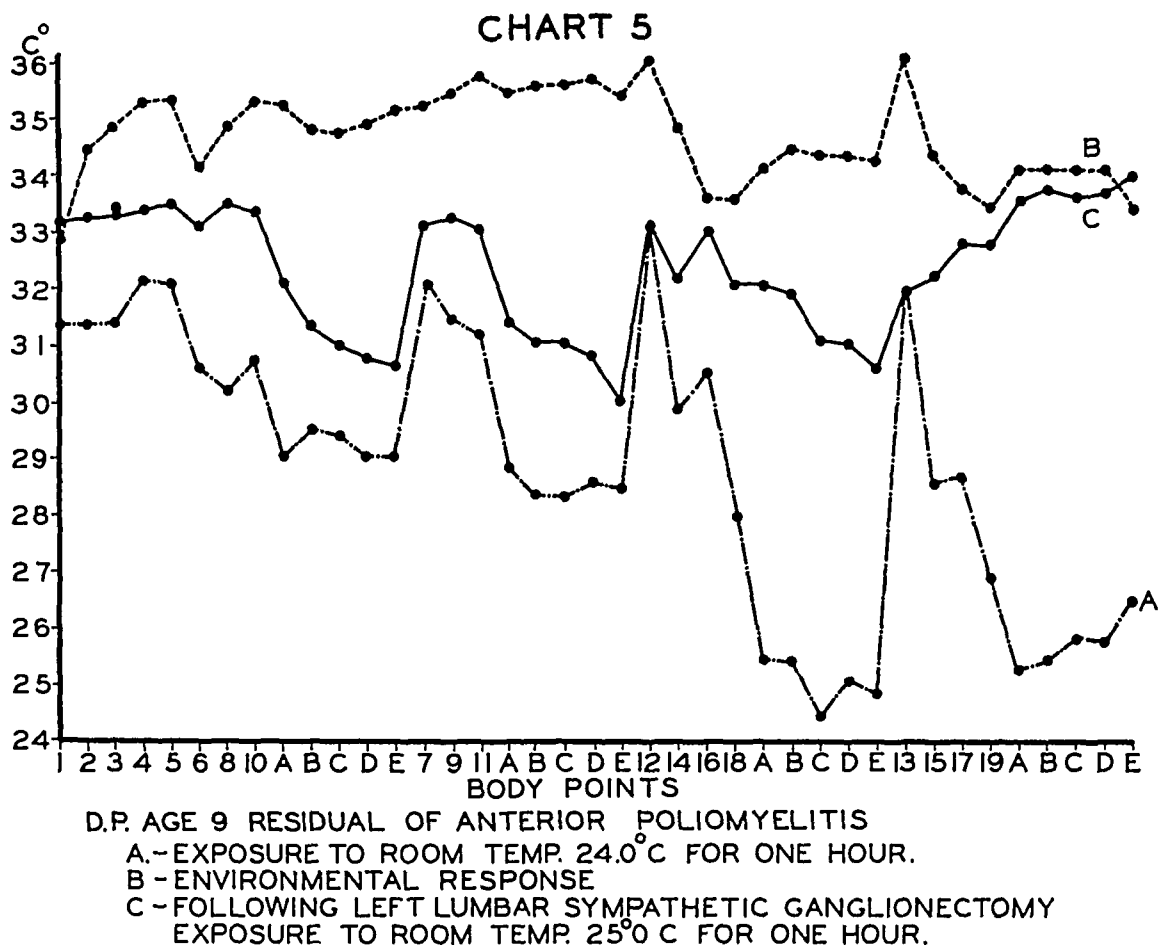


Comment.—During the past two years in a study of thirty individuals with clinical evidence of a peripheral vascular occlusion, there was only one patient on whom the results obtained with the environmental test neither agreed with the clinical impression, nor with the result of other tests used. This patient, a male aged forty years, had marked vasoconstriction of traumatic origin, secondary to a fracture of the first metatarsal three years previously. Maximal rises in temperature of the extremities occurred with spinal anaesthesia and a posterior tibial nerve block. The routine environmental response did not reach the normal level in spite of evidence that this should have occurred. The test was repeated with the addition of a hot-water bottle at 50.0° C. to the feet for the first half-hour of the covered period with a result at the end of the hour in accord with the other tests.

SKIN-TEMPERATURE INDICATIONS

A lumbar sympathectomy ganglionectomy was performed with a maximal response. The impulses from the sympathetic system were apparently of such force that they did not respond in the hour period.

The other tests presented for the differentiation of spastic from organic vascular occlusions are well known and have been adequately discussed elsewhere.^{16, 17, 18, 19, 20, 21, 22} The value of many of them has been proven by long use. From observations based on these tests, peripheral vascular occlusions have been divided into three main groups:



Group I.—Those cases in which no change or slight change occurs in the skin temperature as a result of the test, indicating organic occlusion and no vasospasm. A sympathectomy would be of no value to these individuals. This group is composed largely of cases of advanced peripheral arteriosclerosis and late thrombo-angiitis obliterans.

Group II.—Individuals in which the skin temperature rose to the normal vasodilatation level for the test used, thus demonstrating the absence of an organic occlusion as a basis for the disorder. A sympathectomy offers the greatest possibility of relief in this group. These disorders comprise Raynaud's disease, scleroderma, and a number of less marked vasospastic conditions associated with residual paralyses of anterior poliomyelitis, with spastic paralyses, with chronic arthritis, and with some cases of trauma.

Group III.—Presents a combination of the factors of Group I and II.

Here a rise in the skin temperature occurs as a result of the test, but not to the normal level, indicating the presence of some organic occlusion and some vasospasm. The value of a sympathectomy is determined by the relative amount of organic occlusion present. The early cases of thromboangiitis obliterans are in this class.

None of the tests previously presented is entirely free from disagreeable features and many of them require hospitalization. We do not consider their general application to be as simple as the one we are advocating. Fundamentally, the environmental response and the other differential tests are means of determining the presence or absence of organic vascular occlusions. The presence of vasoconstriction is also shown but whether or not this is pathological can be determined only by clinical observations. Again, so many factors may cause a variation of the degree of peripheral vasoconstriction present that a measurement during exposure of the body to a moderate room temperature reveals nothing concerning the magnitude of the process at other times. It therefore does not seem worth while in actual practice to expose the patient for the hour period. The important measurements are those made in response to the high environmental temperature during the hour under covers as these are the indices of the presence or absence of organic occlusion. Adopting this view we frequently have shortened the test to the covered-hour period. We have occasionally used room temperatures of 30.0° C. or more as a substitute for the rubber sheet and blanket coverings but it has been slower and less reliable in producing a uniform peripheral vasodilatation. The physiological response of the peripheral vessels to high environmental temperatures should be constant, the coverings are simply a convenient method of providing a fairly uniform suitable environment.

SUMMARY.—A simple method of study, requiring no special apparatus excepting a thermocouple for the measurement of skin temperatures, is presented as a test for the presence and degree of organic obstruction in cases of peripheral vascular occlusion. The test is based on the factors of the physical regulation of body temperature and fundamentally is the skin temperature response to high environmental temperatures.

In Part I the skin temperature response of normal subjects to varying room temperatures and to the high environmental temperatures prevailing under a rubber sheet and woolen blankets was established. Under the latter condition uniformly high skin temperatures were found. These temperatures were approximately at the "normal vasodilatation level" of 33.0° C. obtained by other investigators as a result of paralysis of the sympathetic nervous system with general or local anæsthesia. Evidence was presented that the extremities play an important part in regulating the dissipation of body heat in response to changes in the environment by varying the amount of vasoconstriction or vasodilatation.

In Part II the application of the procedure to subjects with peripheral vascular occlusions showed that a failure to reach the normal vasodilatation

level was due to the presence of organic vascular obstruction. In twenty-nine out of thirty cases studied, the level of the skin-temperature response to the covered period was found to be in agreement with that of other tests advocated for the differentiation of spastic from organic vascular occlusions. The skin temperatures of the extremities following a sympathectomy were always at the level predicted by the environmental response.

Ordinary clinical observations furnish fairly accurate information as to the type of occlusion involved in any case of peripheral vascular deficiency. If the result of the environmental response is contrary to the clinical impression, corroboration may be obtained by the use of the other tests.

The ease of clinical application, without danger and with little inconvenience to the patient, recommends the test of environmental response.

BIBLIOGRAPHY

- ¹ Lusk, Graham: *The Elements of the Science of Nutrition*. Saunders, Philadelphia, 1928.
- ² Scott, W. J. M.: An Improved Electrothermal Instrument for Measuring Surface Temperatures. *Jour. Am. Med. Assn.*, vol. xciv, p. 1987, June 21, 1930.
- ³ Benedict, F. G., Miles, W. R., and Johnson, Alice: The Temperature of the Human Skin. *Proc. Nat. Acad. Science*, vol. v, pp. 218-222, June, 1919.
- ⁴ Morton, J. J., and Scott, W. J. Merle: The Measurement of Sympathetic Activity in the Lower Extremities. *Jour. Clin. Investig.*, vol. ix, p. 235, 1930.
- ⁵ Morton, J. J., and Scott, W. J. Merle: Methods of Estimating the Degree of Sympathetic Vasoconstriction in Peripheral Vascular Diseases. *New Eng. Jour. Med.*, vol. xix, p. 204, May 7, 1931.
- ⁶ Maddock, W. G., and Coller, F. A.: Peripheral Vasoconstriction by Tobacco Demonstrated by Skin-Temperature Changes. *Proc. Soc. Exp. Biol. and Med.*, vol. xxix, pp. 487-483, 1932.
- ⁷ Benedict, F. G., and Root, H. F.: The Insensible Perspiration: Its Relation to Human Physiology and Pathology. *Arch. Int. Med.*, vol. xxxviii, p. 1, 1926.
- ⁸ Scott, W. J. M., and Morton, J. J.: Sympathetic Activity in Certain Diseases, Especially Those of the Peripheral Circulation. *Arch. Int. Med.*, vol. xlviii, p. 1065, December, 1931.
- ⁹ Morton, John J., and Scott, W. J. Merle: Methods for Estimating the Degree of Sympathetic Vasoconstriction in Peripheral Vascular Diseases. *New Eng. Jour. Med.*, vol. cciv, pp. 955-962, May 7, 1931.
- ¹⁰ Vincent, cited by Flugge, C.: Untersuchungen über die hygienische Bedeutung einiger Klimatischer Faktoren unbesondere des Windes. *Festschr. z. 60-Geburtstag v. Robert Koch*, Gustav Fisher, p. 639, Jena, 1903.
- ¹¹ Reichenbach, H., and Heymann, B.: Untersuchungen über die Wirkungen Klimatischer Faktoren auf den Menschen. *Ztschr. f. Hyg. n. Infectiouskrankh.*, vol. lvii, p. 1, 1907.
- ¹² Cobet, Rudolph: Die Haut temperatur des Menschen. *Ergeben. d. Physiol.*, vol. xxv, p. 439, 1925.
- ¹³ Benedict, F. G.: Die Temperatur der Menschlichen Haut. *Asher-Spire's Ergebn. d. Physiol.*, vol. xxiv, p. 594, 1925.
- ¹⁴ Foged, J.: Effects of Anæsthetics on Peripheral Circulation. *Hospitaltid.*, vol. lxxii, p. 983, 1929.
- ¹⁵ Ipsen, J.: Les arteres et l'Anesthesia. *Acta Chir. Scandinav.*, vol. lxxv, p. 487, 1929.
- ¹⁶ White, J. C.: Diagnostic Blocking of Sympathetic Nerves to Extremities with Procaine. *Jour. Am. Med. Assn.*, vol. xciv, p. 1381, May 3, 1930.

- ¹⁷ Brill, S., and Lawrence, L. B.: Changes in Temperature of the Lower Extremities Following the Induction of Spinal Anæsthesia. *Proc. Soc. Exp. Biol. and Med.*, vol. xxvii, p. 728, 1930.
- ¹⁸ Morton, J. J., and Scott, W. J. M.: The Measurement of Sympathetic Vasoconstrictor Activity in the Lower Extremities. *Jour. Clin. Invest.*, vol. ix, p. 235, 1930.
- ¹⁹ Scott, W. J. M., and Morton, J. J.: Obliteration of the Vasoconstrictor Gradient in the Extremities under Nitrous Oxide-Oxygen, Ether and Tribromethyl Alcohol Anæsthesias. *Proc. Soc. Exp. Biol. and Med.*, vol. xxvii, p. 945, 1930.
- ²⁰ de Takats, Geza: The Differentiation of Organic and Spastic Vascular Occlusions. *ANNALS OF SURGERY*, vol. xciv, p. 321, September, 1931.
- ²¹ Scott, W. J. M., and Morton, J. J.: The Differentiation of Peripheral Arterial Spasm and Occlusion in Ambulatory Patients. *Jour. Am. Med. Assn.*, vol. xcvi, p. 1212, October 24, 1931.
- ²² Brown, G. E.: The Treatment of Peripheral Vascular Disturbances of the Extremities. *Jour. Am. Med. Assn.*, vol. lxxxvii, p. 379, August 7, 1926.
- ²³ Lusk, Graham: *The Science of Nutrition*. Saunders, p. 133, Philadelphia, 1928.

THE GENERAL CARE OF PERIPHERAL VASCULAR DISEASES

BY MONT R. REID, M.D.

OF CINCINNATI, OHIO

IN THE excitement of new ideas and discoveries with respect to the etiology, diagnosis and treatment of peripheral vascular diseases, enthusiasm for new procedures has all too frequently resulted in discarding or ignoring many of the simple but fundamental principles of treatment which may be of the greatest value. Generally speaking, it is a common fault to discard abruptly the old and to embrace wholeheartedly the new methods of treatment. As a result, many new procedures become overworked, prove disappointing, are almost discarded and then gradually assume their places as valuable adjuncts to the existing therapy of disease. This weakness is particularly manifest when we are dealing with difficult problems in which, at best, our efforts often prove discouraging.

The treatment of peripheral vascular lesions is a difficult problem. In recent years it has become an active challenge to many investigators and notable advances toward its solution have been made. However, the fundamental nature of many vascular lesions seems to me to indicate that in most instances we can only help or ameliorate; that we cannot cure the underlying causes. In such cases it becomes advisable to utilize all procedures that may be helpful, to supplement our major treatments with all those minor details which may be of value in preventing or curing some of the consequences of these vascular lesions. It is my desire to stress the importance of what may be termed the petty details in the treatment of these conditions, for it is our belief that the great majority of patients do not often fully realize their value and all too frequently neglect details of treatment which, if faithfully observed, would prevent many complications.

It is often a difficult matter to make a patient realize the importance of the many precautions and details of treatment that should be observed; it is still more difficult to make him use them constantly and intelligently. Fortunately, almost every patient can be made to understand the reason for the things that he is advised to do if only the doctor will take the time and patience to explain. For examples, it should not be difficult to make a patient know that a reduced circulation means impaired nourishment to tissues and that the many things that he is told to do with respect to position and exercise of his extremities, the avoidance of cold, the care of the skin, *etc.*, are efforts to keep the nourishment of his tissues up to the maximum amount that can be obtained; that tissues with deficient nourishment cannot heal readily nor combat infection normally and that consequently any abrasion or infection of the skin should be given extraordinarily good care; that each arterial spasm leaves some permanent damage to tissues; or that infected

vessels should no more be traumatized than boils or other infections. Yet, when the reasonableness of advice has been made perfectly clear and understandable, the actual observance of it must be watched and checked until one is sure that he has obtained the patient's maximum interest and coöperation. General instructions will not be carried out until the details have been so frequently checked that they become a matter of routine and constant consciousness on the part of the patient. Commendation, of course, is helpful to secure interest and coöperation, but usually it is quite essential to observe that some detail of treatment might be improved or changed at each visit. "The feet are cold; you had better wear two woolen socks during this cold weather." "The skin is somewhat rough about the heel and I think you can grease that part a little more thoroughly." "The seam of your sock is making a groove on your toe or foot; you had better have some seamless ones knitted." "A quart of water is not enough; you should not drink less than three quarts in the twenty-four hours." "The end of your toe looks a little white as if a blister may be going to form; you should stay in bed for a couple of days." "These shoes are too tight; you must get larger ones." "How much do you move your toes when you are standing?" "An electric pad in your office would be helpful." These are but a few of the many ways that one may keep a patient interested in these details until they become a matter of a fixed routine with him. A good index of one's success along these lines is the development of ideas or the offering of suggestions on the part of the patient. His interest is then definitely aroused; frequently he makes real contributions toward the treatment of his own condition. The treatment of peripheral vascular lesions becomes most effective only when there is complete coöperation of the patient.

The fact that the vast majority of cases of peripheral vascular diseases are seen or diagnosed only after some serious complications, such as infection and gangrene, have appeared, should lead to a determined effort of the medical profession to make earlier diagnoses and, thus, to institute treatment and to enlist the patient's coöperation which would undoubtedly reduce the incidence of complications that so frequently mean the loss of extremities. The early adoption of a routine care and the simpler treatments would make unnecessary many amputations; many patients who now lose extremities would live out their lives without serious or tragic peripheral handicaps. The routine examination of all peripheral vessels would result in much earlier diagnoses; the true nature of many cases that are now treated for weeks, months and years for pain, fallen arches, and cramps would be established. If it were the rule to record the pulse from an examination of the pedal rather than the wrist pulses many more cases of early vascular trouble would be detected.

It is important to determine the level of a resting extremity, which will result in the optimum circulation. A little reflection on the various grades of peripheral vascular deficiency makes it obvious that this optimum level must be determined for each individual case. The actual force behind the

blood circulating through the peripheral arteries is subject to a wide variation; it is probably never identical in any two cases. A fairly accurate idea can be determined by the use of the Pachon oscillometer but this instrument is unfortunately at the disposal of very few doctors. A less accurate but practical idea of the level of optimum circulation can be obtained from observations on the fullness of the veins when the extremity is put at

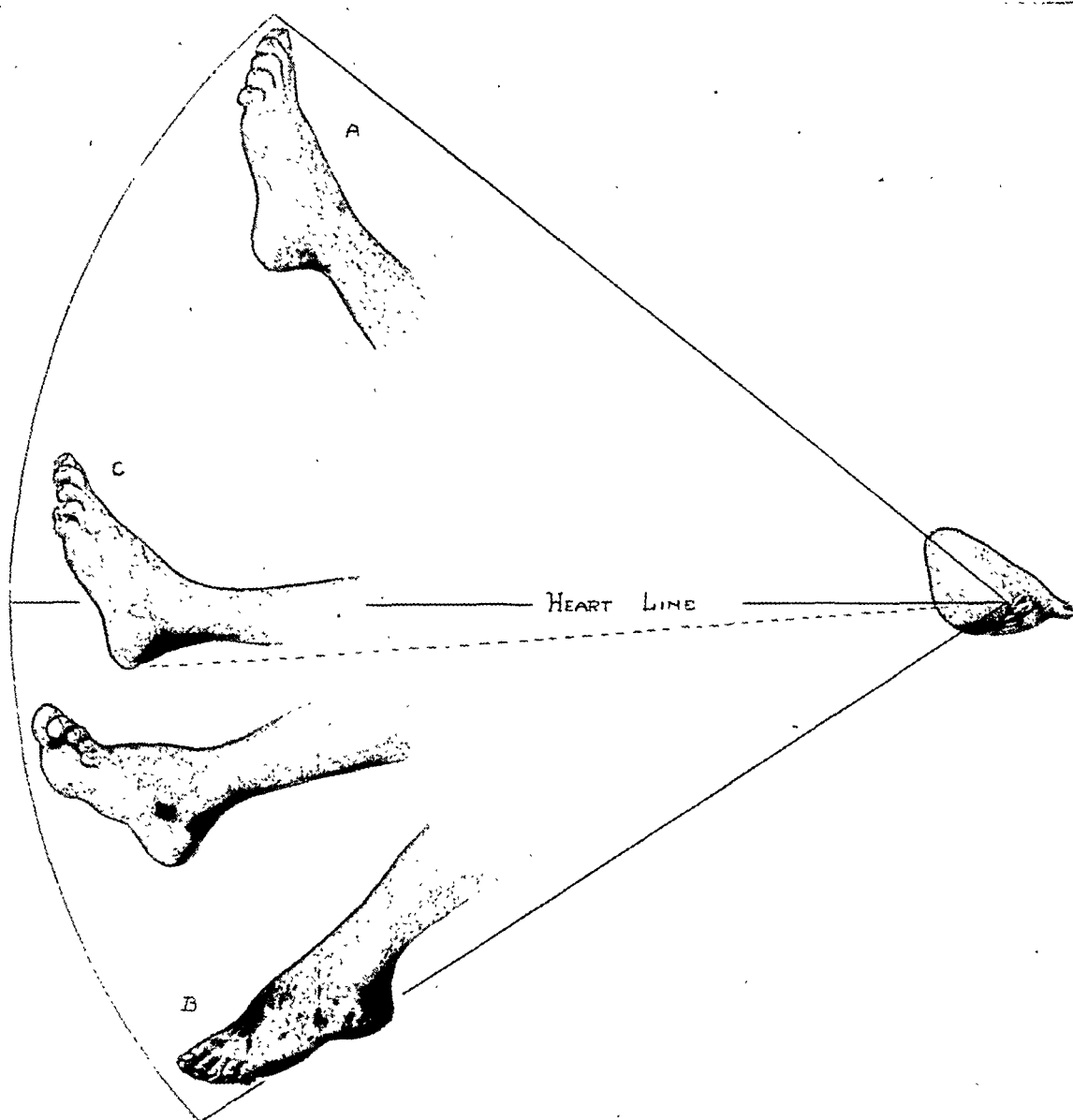


FIG. 1.—Illustration of the effect of position, with respect to the heart, upon the circulation of a foot in a case of peripheral vascular disease. Too great elevation above the heart is far more detrimental to the circulation than is a similar degree of dependency. (A)—The foot is pale and cadaveric; the veins are collapsed and produce grooves in the skin. (B)—The foot is congested; the veins are distended and produce elevations of the skin. (C)—Position of optimum circulation. The veins are neither distended nor collapsed. This level, with respect to the heart, varies with the degree of circulatory embarrassment and must be determined for each case by gradually elevating the foot from position B toward A and noting at what level the effect represented in C occurs. It is always somewhat below the level of the heart.

different levels with respect to the level of the heart. A foot that is allowed to hang over the side of the bed may become congested and cyanotic and the veins of it markedly distended. The effectiveness of the feebly circulating blood becomes reduced by the back-pressure of the venous blood and

the tissues of the foot suffer a reduced nourishment. If, on the other hand, the foot is elevated above the level of the heart it becomes blanched and cadaveric in appearance and its veins become collapsed, usually appearing as grooves in the skin. The weight of gravity of the column of arterial blood is seriously reducing the amount of blood that can be forced into the capillary bed and the tissues suffer a reduced nourishment. In the one instance it is the back-pressure of the venous blood that is harmful; in the other it is the back-pressure of the column of arterial blood. Somewhere between these two extremes is to be found the point of maximum circulation and consequently the greatest nourishment of tissues. We believe this point to be at the level where the veins are neither collapsed nor distended, when they are visible and apparently on the same level with the surface of the skin. This can be determined by the slow elevation of an extremity that has been allowed to hang down until the veins become fully distended. At a certain point, usually three to six inches below the level of the heart, the pressure within the veins can be seen to give way suddenly. Near to the point of this observation they will assume a capacity that neither distends nor retracts the skin. (Fig. 1.) This is an observation that the patient can make and in which he takes a great interest. Once the level of optimum circulation has been determined and the patient made to realize its importance he will usually endeavor to place his affected extremities at the best level whenever they are at rest. Many of my patients try to observe this position of optimum circulation whenever they are sitting or lying down—in the library, office and at the dining table, on the couch and in bed.

For some reason there is a fairly general impression that in cases of peripheral vascular disease the affected extremities should be elevated well above the level of the heart. In search of a reason for this practice I have wondered if it has not been adopted from the practice of high elevation of badly infected or œdematous normal extremities. The problems are, of course, in no way similar. There can be no question that many extremities are unnecessarily sacrificed as a result of rest and elevation far above the level of optimum circulation. It is difficult for me to refrain from criticism or comment when I visit hospitals and see all cases of arteriosclerotic and Buerger's disease of the extremities lying in bed with the affected parts white and cadaveric elevated on three and four pillows far above the level of the heart. Gangrene in many cases is certainly being hastened by this rather general practice.

It is usually easy to demonstrate to a patient the value of a certain amount of exercise whenever infection and gangrene are not a contra-indication. Voluntary movement of the ankle and toes will often cause a striking improvement in the color of an affected foot that has been allowed to hang still until it becomes red and cyanotic. We make our patients stand for a few minutes and then observe for themselves the improvement which comes with movement of the toes and ankles. The congestion is usually accompanied by a subjective sensation of tingling or tightness. With this

knowledge the coöperative patient will always move his toes and feet whenever he experiences this sensation. He soon learns that it comes most often when he stands or sits still. The harm of too much exercise and the meaning of the pains of intermittent claudication should also be explained.

In our experience it is best to require a short period of hospitalization in order to teach patients, when indicated, to carry out accurately the valuable exercises of Buerger and Allen. The cycles of these exercises in which time is devoted to heat, dependency with exercise and elevation are, of course, familiar to everyone. They should be a most important part of the routine of the patient's self-help. In addition to their unquestioned value they make the patient conscious of the care and duty he owes himself.

Circulation is unquestionably better when the skin is soft and delicate. It allows the freest breathing which normally takes place through the skin. It not only reduces the dangers of infection incident to cracks and calluses but it allows a better circulation than is possible when the skin is thickened, non-pliable and binding. Careful washing and greasing or oiling of the skin should be persisted in until it becomes as nearly like a child's skin as it is possible to get it. In the beginning of treatment this may necessitate treatment of the skin twice daily until the calluses and thickened, cornified epithelium disappear. It does not seem to matter much what lubricant is used; we usually employ cocoa-butter or lanoline and insist that it be rubbed into the skin until it seems to disappear. It is surprising how much enthusiasm the patient will take in the care of his skin if he fully understands its importance and gets the proper recognition for his efforts.

The vast majority of the complications of peripheral vascular disease occur during cold weather. Although this is true for both the degenerative and inflammatory processes (of the vessels) it is especially true in the angiospastic conditions. If then one can institute treatment or a mode of life which will, in a large measure, obviate the harmful effects of cold, the dangers that these patients constantly run may be lessened. One cannot accept the patient's assertion that his feet, for example, are warm. His subjective appreciation of warmth and cold is most untrustworthy. Many times a patient will say his feet are warm when if he himself feels them with his hands he will appreciate that they are icy cold. Woolen socks with or without fleece-lined shoes should be insisted upon until the feet perspire, feel uncomfortably warm subjectively and definitely warm objectively. As a result of the doctor's persistence and suggestions the determination to keep his extremities warm often becomes the patient's hobby. I am told by Dr. George Lawson, of Roanoke, Virginia, that he has a patient with severe Raynaud's disease, who for many years has not had a single arterial spasm. The skin of his hands has become soft, pliable and very delicate; the stiffness of the fingers and infiltration of the tissues have disappeared. His work is inside; under no conditions will he subject his extremities to cold. When he goes outside his hands are always covered with previously warmed fleece-lined or woolen gloves; he takes scrupulous care in the washing and

greasing of his skin. A patient of ours who has apparently recovered from an attack of severe thrombo-angiitis obliterans has had made a pair of fur-lined trousers (Fig. 2) to keep his legs warm when he is riding horseback or hunting ducks. By means of woolen socks worn day and night, electric heaters in his car and at the office, he never allows his feet to get cold. At one time there were weeks when it seemed certain that he would lose his leg at any time; now he plays golf and tennis, rides and hunts as he desires. Another patient suggested and secured the fleece-lined shoes illustrated in Fig. 3. These are just a few examples of the fruits of interested and cooperative patients. Do not discourage this initiative and interest. Let patients devise

and tell you the very things you would like them to do. Success will be greater because these things are their ideas and the situation can always be handled so as not to



FIG 2.



FIG 3

FIG 2 —Sheep skin boot and leggings designed by a patient with thrombo angiitis obliterans to keep his foot and leg warm when riding or hunting

FIG 3 —A shoe lined with wool suggested and used by a patient to keep his feet warm during the winter months

lose patients' respect and admiration. Besides, how many doctors will devote the time to details, the patience and effort to accomplish these ends as well?

There do not appear to be any harmful effects from overheating. On the contrary, it is our belief that sweating of the extremities is a good thing, not only to improve the delicacy of the skin and the inflammatory processes beneath it, but to help the actual nourishment of the tissues. Certainly it seems to hasten the disappearance of the board-like rigidity of the toes and fingers.

It is scarcely necessary to stress the seriousness of wounds and infections of the extremities in association with peripheral vascular disease; it is well appreciated. It could be better realized by patients to the end that they would seek treatment or advice for the most trivial wounds, blisters, infec-

tions or discolorations of the skin. No matter how slight they may be or appear to be it is a good policy for patients to realize that they mean stopping work and going to bed, with the most meticulous care of them until they are completely healed. Unfortunately, through ignorance, a great many patients do not seek advice until some innocent-looking lesion has developed into a dissecting and spreading infection. The dangers incident to the cutting of calluses and nails have been stressed by Allen and many others; it is of the utmost importance that the patient fully understand them. When, in the care of the feet and hands, any blood is drawn, patients should seek the treatment of a doctor until they become thoroughly familiar with what to do.

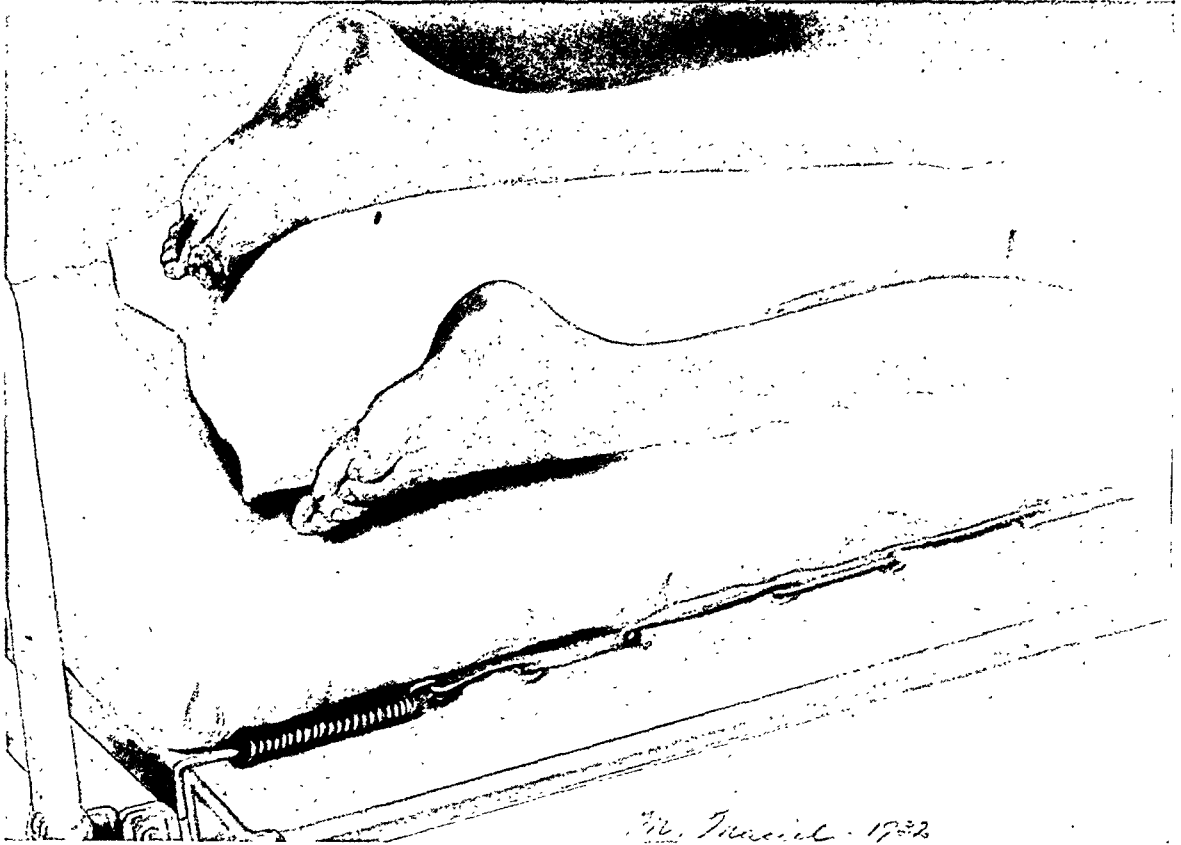


FIG. 4.—Illustration of dependent drainage in order to lessen the spreading of infection from an infected toe into the sole and dorsum of the foot.

It is considered beyond the scope of this paper to discuss the details incident to the performance of amputations and the treatment of infected wounds. These vary somewhat in almost every clinic. Generally speaking, the accepted procedures that the surgeon knows and uses best should be employed. For infections we prefer wide-open wounds and the use of Dakin's solution. In order to lessen the spreading influences of gravity we usually adopt the position illustrated in Fig. 4 in the case of amputated infected toes where the tendency of the infection to go into the sole of the foot is very strong. In the amputation of infected toes and fingers we have been anchoring the tendons to their sheaths before dividing them. (Fig. 5.) It should tend to lessen the dragging of infection upward if the proximal end of the divided tendon is not permitted a wide retraction.

We have had a few instances which strengthen our belief in the fundamental principle that trauma, in the presence of inflammation, may do harm. In thrombo-angiitis obliterans, especially, the vessels are inflamed and in the more acute cases the patients are frequently conscious of pain in the popliteal and other vessels. In one instance the taking of blood-pressures in the affected leg was followed by damage to the artery and rather sudden disastrous results. In addition to the direct trauma that a tourniquet may do to diseased vessels the temporary stasis of blood distal to it should certainly encourage the extension of a thrombotic process. The possible trauma incident to certain forms of exercise (example, horseback riding) or to passive massage should always be considered.

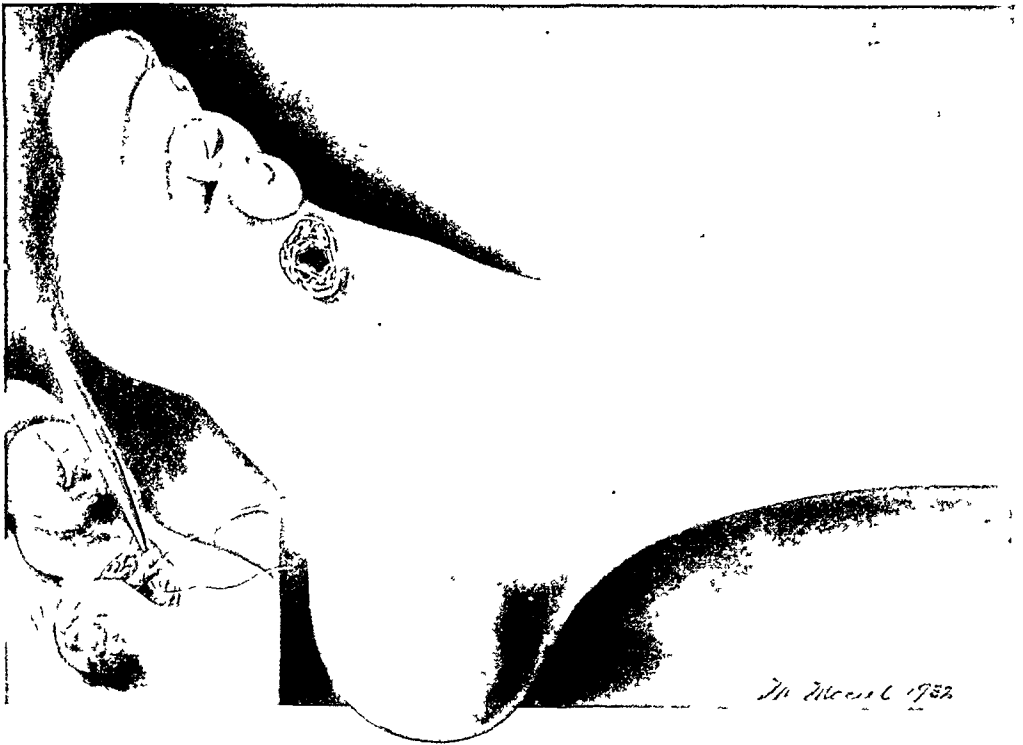


FIG. 5.—Illustration of a method of anchoring tendons to their sheaths when amputating infected or gangrenous toes. This method avoids a wide retraction of the tendons and probably lessens the spreading of infection into the foot.

In the cases of amputation for gangrenous and infected extremities, not associated with primary vascular disease, we have usually employed the use of double tourniquets, performing the amputation between them. (Fig. 6.) This technic prevents the back-flow of the blood and lymph from the infected extremity into the field of operation and thus should lessen the chances of infecting the operative wound. The necessary manipulation of the infected area during the procedure of amputation probably throws a great many organisms into the blood and lymph which would be spilled into the operative field if the distal tourniquet were not used. In those cases of amputation necessitated primarily by vascular diseases, we do not take the risk of the possible damage of the proximal tourniquet; the distal one alone is used.

CARE OF PERIPHERAL VASCULAR DISEASES

The fluid intake of patients with peripheral vascular disease should be very large. A simple statement to this effect is not as efficacious as to require that a daily written record be kept. Only after a patient has established a fixed routine of drinking water by actual measurement can he be trusted to take the four thousand or more cubic centimetres that should be drunk in each twenty-four-hour period. If the intake by mouth is constantly large the giving of fluids subcutaneously, intravenously or by duodenal tube becomes less necessary.

In some instances the blood-pressure may be elevated and the circulation beneficially accelerated by the use of thyroid extract. Many patients with peripheral vascular disease are found to have a lowered basal metabolic rate.

In the cases of peripheral vascular disease it would appear just as important to try to eradicate all foci of infection as it is to do so in cases of arthritis, myositis or neuritis. This procedure would appear especially logical in the instances of thrombo-angiitis obliterans and other inflammatory

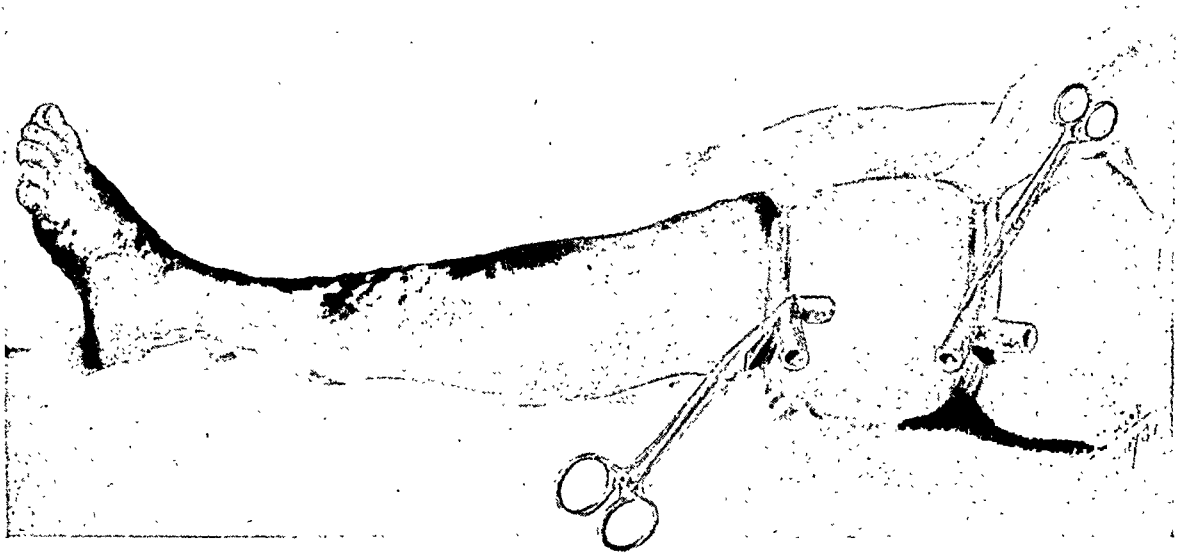


FIG. 6.—Illustration of the use of two tourniquets to lessen infection, through venous and lymphatic return, of the stump when amputating infected extremities not associated with peripheral vascular diseases. In the latter case the distal tourniquet alone is used.

conditions in which, as is usually the situation, no definite portal of entry for the infection can be found. In some cases we have tested patients for their sensitivity to vaccines made from their own organisms recovered from the sinuses, teeth and intestines, and have treated them with vaccines to which they are most sensitive. As usual, it has been difficult to evaluate this vaccine therapy.

In view of the uncertainty and contradictory evidences of the harmful effects of tobacco, it has become our policy to discontinue its use whenever it can be done.

This paper must not be construed to minimize the great value of employing operations upon the sympathetic nervous system or of giving foreign protein stimulation when indicated, nor of utilizing the various means of estimating vascular sufficiency by a study of skin and tissue temperatures under different forms of anæsthesia and foreign protein reaction and by

employing oscillometers, tourniquets, *etc.* The control of pain by means of drugs and peripheral anæsthesia has not been discussed.

An attempt has been made to emphasize the value of what might be called the details of the general treatment of peripheral vascular disease, which the author thinks are important but often overlooked. It may be objected that many of the things that have been discussed are impractical with the class of patients who seem to be most frequently afflicted, but with them much more could be done than is now being accomplished.

The specific nature of any given case might call for alterations of or additions to what has been discussed. In the inflammatory, spastic and toxic conditions which, with good care, tend to run a definite course toward spontaneous healing and the establishment of a more or less satisfactory collateral circulation it seems to me that the incidence of complications and amputations could be materially reduced by adhering to what has been designated in this paper "The General Care of Peripheral Vascular Diseases." I am not at all sure that a long period of bed rest would not be as useful in preventing the spreading and in hastening the healing of inflamed blood-vessels as it is in the case of pulmonary tuberculosis.

SUMMARY.—(1) In the management of peripheral vascular diseases it is of the utmost importance to secure and maintain the interest and active coöperation of patients. Fortunately, most of the therapy is reasonable and easily understood if only the time and patience are devoted to explaining its significance.

(2) The position of maximum circulation of the affected parts when at rest should be determined for each case. A simple method of determining this position is described. Too much elevation more effectively reduces nourishment and more frequently causes gangrene than does too much dependency.

(3) The effect of cold is evident from the high incidence of complications during the winter months. The affected extremities should never be allowed to become cold. Moderate sweating improves the texture of the skin and the nourishment of the tissues beneath it.

(4) By means of baths, oils and greases the skin should be made as soft and delicate as possible.

(5) The most trivial wounds and infections should be treated as major complications until they are completely healed.

(6) Any form of trauma to inflamed or diseased vessels should be avoided by both the patient and doctor. The possible dangers of the tourniquet and blood-pressure apparatus are discussed, as well as certain forms of exercise and passive massage.

(7) In order to teach patients the Buerger or Allen voluntary exercises a short period of hospitalization is probably desirable.

(8) Amputations performed between two tourniquets for gangrenous and infected extremities probably reduce the incidence of infection of the

stumps. If, for fear of damage to tissues and blood-vessels, the use of a tourniquet is contra-indicated, the distal tourniquet alone may be used.

(9) The fluid intake should be established and maintained on a high level.

(10) In some instances the use of thyroid extract may help to improve the circulation.

(11) All foci of infection should be eliminated.

(12) It is our policy to advise abstinence from the use of tobacco and alcohol.

(13) The routine examination of all peripheral pulses would result in earlier diagnoses of peripheral vascular diseases and would make possible the avoidance of many complications which are so frequently the direct cause of amputations.

OBSERVATIONS ON SYMPATHETIC VASOMOTOR PATHWAYS

BY ASHLEY W. OUGHTERSON, M.D., SAMUEL C. HARVEY, M.D.,
AND HELEN G. RICHTER, M.D.

OF NEW HAVEN, CONN.

DURING recent years there has been a widespread interest in the surgical treatment of a group of diseases which manifest themselves by a dysfunction of the sympathetic vasomotor system. While the good results following operative procedures have been steadily increasing, they have not always fulfilled expectations. This may be explained, in part, on the basis of poor selection of cases and as more exact means of demonstrating vasomotor dysfunction have been developed the results from operative procedures on the sympathetic system have accordingly improved. Another source of error has been the use of operative procedures by which the sympathetic vasomotor pathways have not been adequately removed or interrupted. This was particularly evident during the developmental phases of the surgery of the sympathetic nervous system. While the need for more exact operative procedures has stimulated investigation of the pathways by which these fibres reach the peripheral blood-vessels the central connections of the sympathetic ganglia have not in recent years received as much attention. It is the purpose of this paper to report some observations on the central connections of the sympathetic vasomotor fibres in man as well as in laboratory animals.

CASE RECORD.—Symptoms suggesting Raynaud's syndrome with generalized vasomotor dysfunction and superficial gangrene of the right hand and left foot. Dorsal sympathectomy right arm and lumbar sympathectomy left leg. Relief of symptoms but six months later novocaine injection of peripheral nerves caused rise of temperature in right arm and left leg.

Admission.—March 17, 1931 (Unit No. A-849), Mr. A. B., aged forty years, referred by Dr. Wilder Tileston, of New Haven, with the complaint of pain and ulceration of the left great toe.

Anamnesis.—The patient, a plumber, had been in good health until 1927, when he noticed "rheumatism" in his legs. (Noted as stiffness and pain on arising in morning and relieved by exercise.) In 1929, he developed pain in the calves of his legs after walking about a hundred yards, the pain always being relieved by rest. These symptoms increased until about six months before entry to the hospital, at which time he consulted an orthopædist who prescribed arch supports which completely relieved the pain in his legs. Coldness of the feet was first noted in December, 1929, following severe exposure while out of doors. During the year preceding admission he had noted marked color changes of both the hands and feet. This was particularly marked in the feet after exposure to cold water, when they became very cyanotic. Four months prior to admission several small blisters developed on the first and fifth toes of the left foot. These blisters discharged a small amount of serum and on healing left a small pit in the skin which for some time remained tender. Some of the larger of these blisters developed into ulcerative lesions which healed slowly. Coincidental with the skin lesions he developed a dull throbbing pain in the left great toe.

SYMPATHETIC VASOMOTOR PATHWAYS

Physical Examination.—This showed a rather undernourished man with no abnormal findings except in the extremities. The upper extremities were normal except for a few small blisters two to three millimetres in diameter on the index finger and thumb of the right hand. On the plantar surface of the left great toe, there was a partially healed superficial ulceration. The first and fifth toes showed numerous small scars in the skin at the base of the nails. The nails also showed evidence of retarded growth. There was no evidence of arteriosclerosis either on physical examination of all the palpable arteries or by röntgenographical examination. The dorsalis pedis arteries could not be palpated in either foot but there was good pulsation of the posterior tibial arteries. Röntgenograms of the feet showed slight atrophic changes of both the tarsal and metatarsal bones and some slight irregularity of the articular surfaces. All the other laboratory findings, including blood, urine and serological examinations, were negative.

Subsequent Course.—The vasomotor responses were studied in a constant temperature room by means of the Leeds and Northrup Multiple Point Temperature Recorders. These findings are shown in Chart I and in general demonstrated a mild type of vaso-

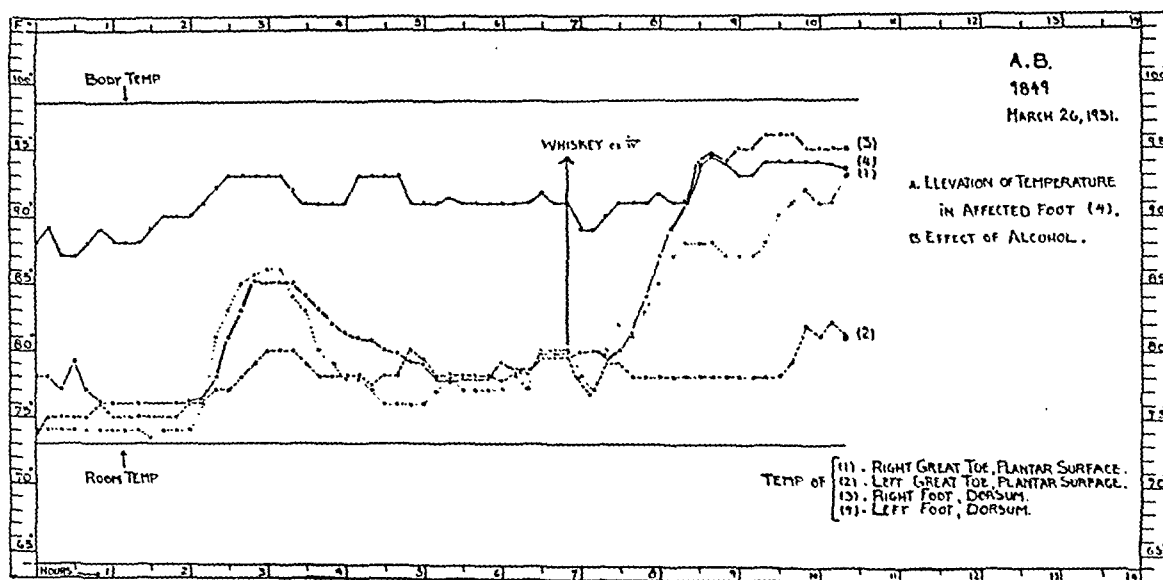


CHART I.

motor instability which was somewhat more marked in the lower extremities. The ulcers on the feet rapidly improved under a short period of conservative treatment, and the patient was discharged to await further developments. For a short while there was some improvement but again the symptoms returned worse than ever and he was advised to enter the hospital for sympathectomy. Two days before the date set for his second admission he entered the hospital with an attack of acute appendicitis. Following the removal of an acute appendix under ethylene anaesthesia the patient made an uneventful convalescence and was discharged home June 15, 1931, to return later for sympathectomy. During the next few months his appetite improved and he gained twenty pounds. He stated he had not felt so well for years and his symptoms of vascular disease completely disappeared. He continued to work at his trade as plumber, until September, 1931, when, coincident with loss of appetite and twenty pounds in weight, the vascular symptoms returned in an even more exaggerated form and he entered the hospital October 5, 1931, for sympathectomy.

During this last attack the lesions had become more pronounced in the upper extremities and especially in the right hand. The vasomotor disturbances were more pronounced in both the hands and feet and he now presented a fairly typical Raynaud's syndrome. Atrophic changes were pronounced in the left great toe and the right index finger, in both of which the skin was a tense shiny red and both presented ulcerations at the base

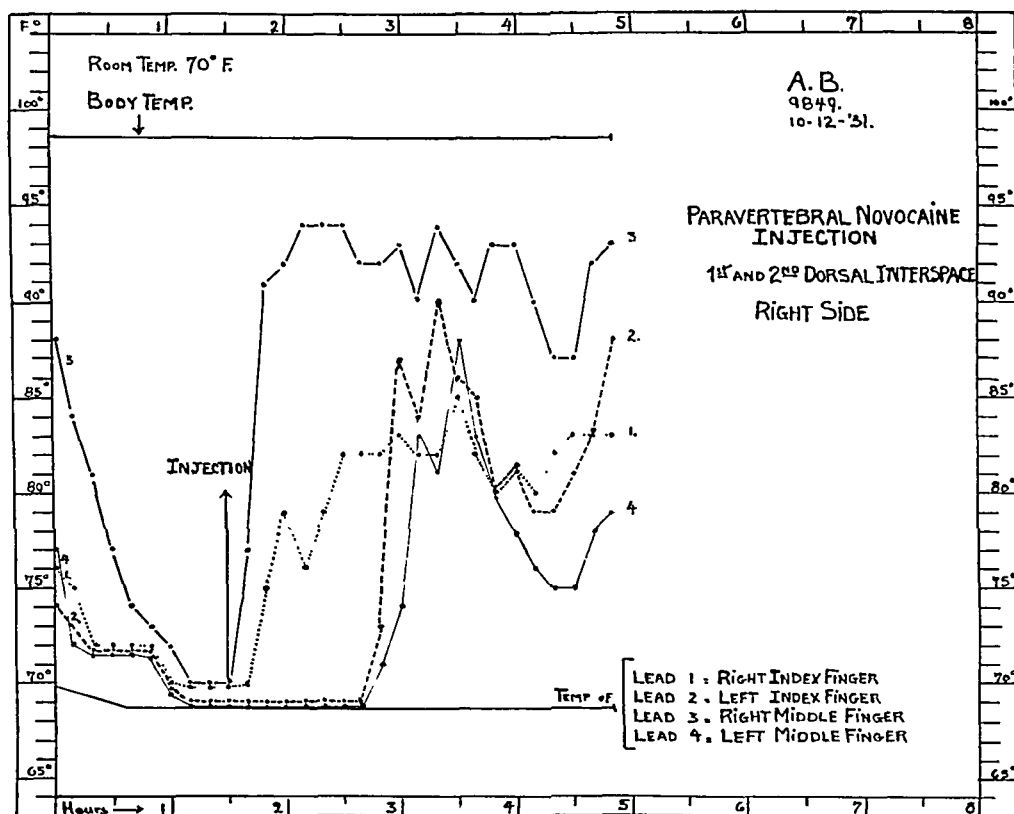


CHART II.

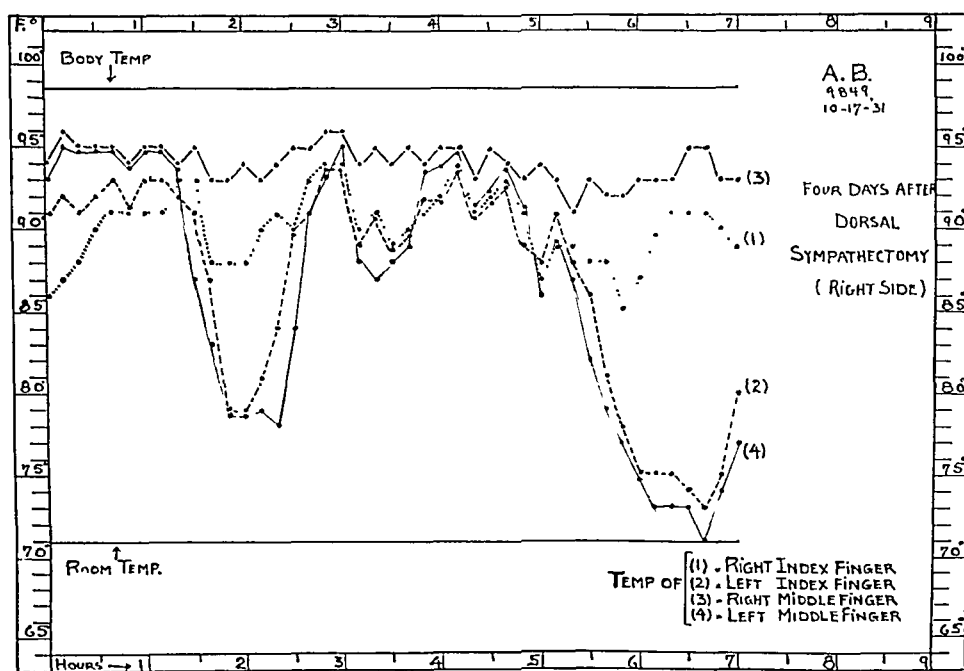


CHART III.

SYMPATHETIC VASOMOTOR PATHWAYS

of the nails. Chart II shows the effect of paravertebral novocaine injection of the upper thoracic ganglia.

Dorsal Sympathectomy.—October 13, 1931, avertin-novocaine anaesthesia. Through a transverse incision over the second rib posterior the thoracic sympathetic chain was exposed on the right and the stellate ganglion and the trunk as far down as and including the second thoracic ganglion was removed.

Post-operative Notes.—The patient made an uneventful recovery and Chart III shows the temperature record of the extremities on the fourth post-operative day. There



FIG. 1.

was also marked subjective improvement. Figure 1 shows the areas over which there was complete absence of sweating indicating that the sympathectomy had been complete. It is interesting to note that this patient did not show a Horner's syndrome.

Lumbar Sympathectomy.—October 24, 1931, gas oxygen-ether anaesthesia. Through a left rectus incision the lumbar sympathetic trunk was exposed and a portion of it removed, including the second, third, fourth and fifth ganglia.

Post-operative Notes.—Following this operation he developed a mild pneumonic process which quickly cleared. There was marked subjective and objective improvement

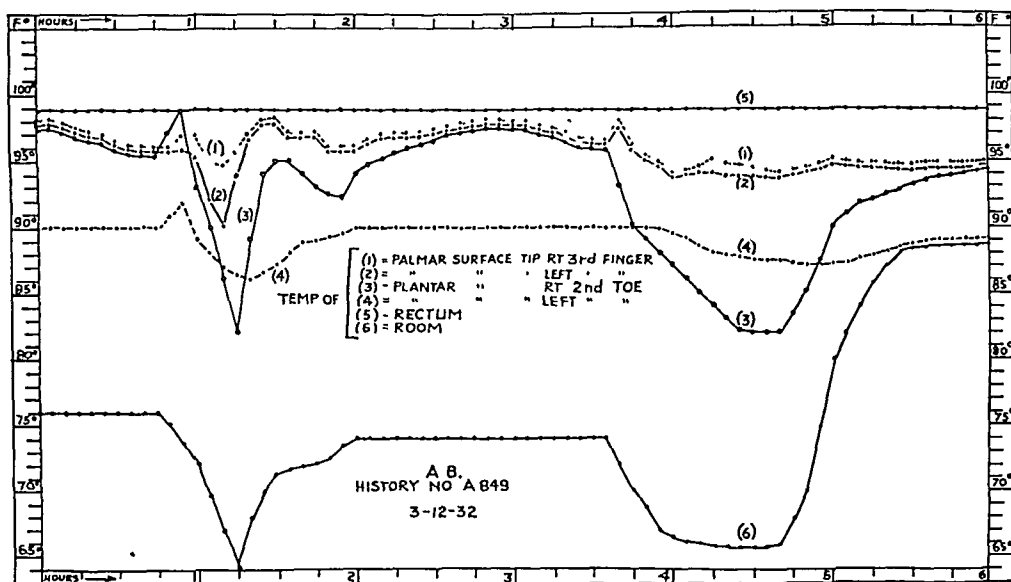


CHART IV.

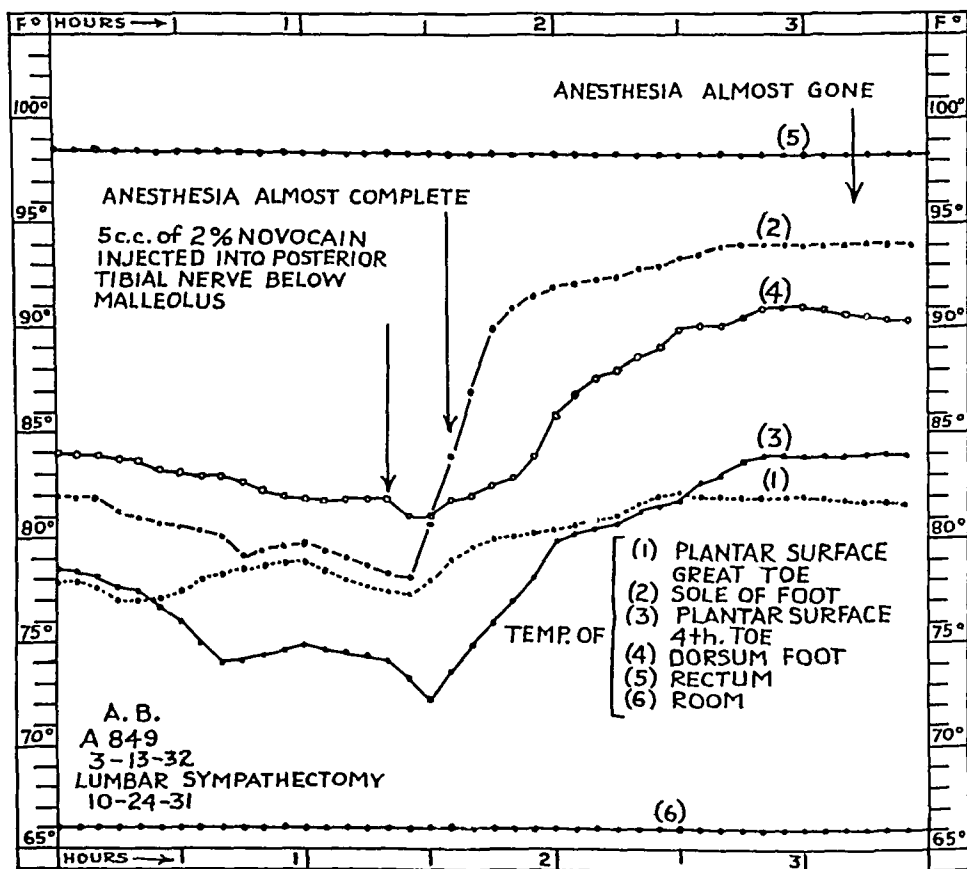


CHART V.

SYMPATHETIC VASOMOTOR PATHWAYS

of the left foot and the pain in the left great toe disappeared. On washing the right hand in cold water three weeks after the dorsal sympathectomy there was distinct evidence of vasomotor spasm but of a mild degree. The patient was discharged home on November 7, 1931.

Interval Notes.—March 15, 1932. Since leaving the hospital he had gained twenty pounds, although he was still ten pounds under his maximum weight. There had been subjective and objective improvement in all extremities but particularly marked in the right arm and left leg. He had noted that the left hand still underwent marked color phases and occasionally on exposure to cold water he had noted slight color changes in the right hand. All ulcerative lesions had completely healed. There had been a marked increase in the rate of growth of the nails in the sympathectomized extremities particularly on the left foot, where it was necessary to cut the nails three to four times more often than on the right foot. He had noted no evidence of perspiration on the right

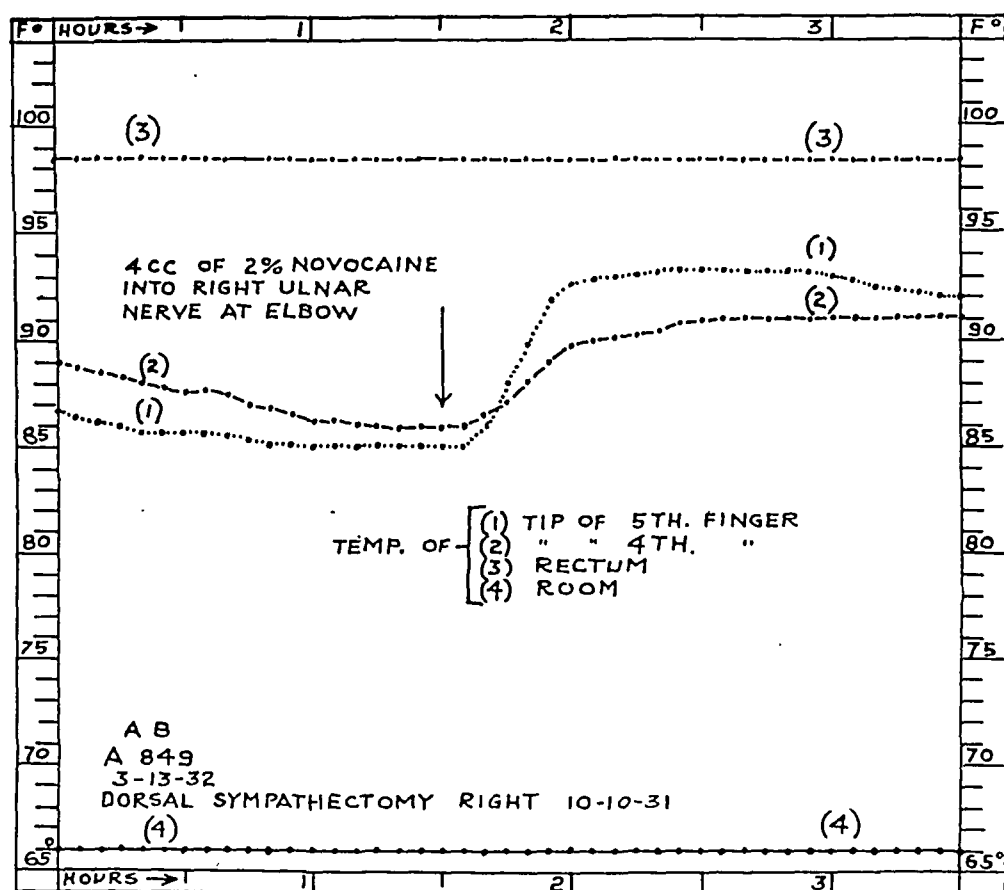


CHART VI.

hand but had occasionally noted one spot of perspiration on the sole of the left foot. There was a marked subjective feeling of warmth in the right hand and left foot.

Comment on Temperature Studies.—March 15, 1932. The patient was placed in the constant-temperature room, and records were made of the temperatures of both upper and lower extremities. Chart IV shows the response of the temperature of the extremities to changes in room temperature. In general there was a tendency for the right hand and the left foot to remain at a higher temperature as a result of the interruption of the sympathetic fibres to these extremities. This was particularly noticeable when there was a rapid change of environmental temperature demonstrating a greater range of temperature variation in the normal limbs. It was furthermore found that if the extremities were exposed to a lower room temperature (that is, 65° to 70°), there was a slow fall of temperature of the sympathectomized limb. After the temperature of the left foot had reached a low level, the left posterior tibial nerve was injected with novo-

caine just below the malleolus, and, as shown in Chart V, there was an immediate rapid rise in the temperature of the foot accompanied by subjective and objective evidence of vasodilatation. There was some difficulty in demonstrating this phenomenon in the right hand, and the temperature changes were never as great. However, they were likewise present. (Chart VI.) These findings suggest that there are still vasomotor fibres intact in the peripheral nerve to the extremities and that when these are blocked with novocaine that there is a release of vasoconstriction, with the resulting rise in temperature in these extremities. Because of the extent of the operative procedures and the number of ganglia removed and because of the sweating reaction obtained after operation, it had been thought that the sympathetic vasomotor fibres in the extremities had been interrupted. The above findings suggest that there are sympathetic pathways which are not interrupted by the usual operative procedures, and it seemed desirable to further investigate this phenomenon by experimentation on laboratory animals.

OBSERVATIONS ON SYMPATHETIC VASOMOTOR PATHWAYS IN DOGS

It is not within the limits of this paper to completely review the work which has been done in determining the course of sympathetic vasomotor fibres in laboratory animals, but rather merely to present a summary of the findings of some of our experiments, which will later be reported elsewhere in detail. Dogs were used in these experiments because of the fact that most of the previous investigations on the course of the vasomotor fibres have been carried out on this animal. In recent years the pathways by which sympathetic vasomotor fibres reach the peripheral blood-vessels after leaving the paravertebral chain have been carefully investigated. Since the work of the English anatomists and physiologists, namely Gaskell, Langley, Bayliss and Bradford, the levels at which the sympathetic vasomotor fibres leave the spinal cord and join the main sympathetic chain have been considered well-established facts. Langley carried out most of his investigation using the cat as a laboratory animal. The procedure by which he demonstrated the levels at which connector fibres left the spinal cord was to isolate the spinal roots and stimulate these at various levels; at the same time observing the appearance of sweat droplets on the footpad. He also used some animals having white footpads in which flushing as a result of vasodilatation could be observed. Gaskell used anatomical methods, and in the dog studied the distribution of the small medullated fibres in the anterior roots and the relation of their distribution at various levels to the presence of these fibres in the gray rami. Bayliss and Bradford, also using the dog as the experimental animal, studied the effect of stimulation of individual nerve roots as measured by the increase in size of the limb contained in a plethysmograph. These studies all indicated that the majority of the sympathetic vasomotor fibres left the spinal cord in the anterior root from the level of the first thoracic to the third or fourth lumbar vertebræ.

In the experiments carried out in this laboratory, the temperature changes in the feet were used as an index of the blood flow in the extremities. It was found that in dogs under amytal anæsthesia when the femoral artery was ligated below Poupart's ligament there was a fall in the temperature of the extremity. Following this if the spinal cord was transected in the thoracic region there was an immediate rise in the temperature of the extremity. It was also found that transection of the cord as low as the fifth or sixth lumbar vertebræ resulted in an immediate rise in the temperature of the foot as shown in Chart VII.

The work of previous investigators had shown that the majority of these fibres left the spinal cord between the level of the tenth thoracic and third lumbar vertebræ. Under the same conditions as previously stated it was found that if the spinal roots were sectioned extradurally from the level of the eleventh thoracic to the third lumbar, there might or might not be a rise in the temperature of the extremity. Following

SYMPATHETIC VASOMOTOR PATHWAYS

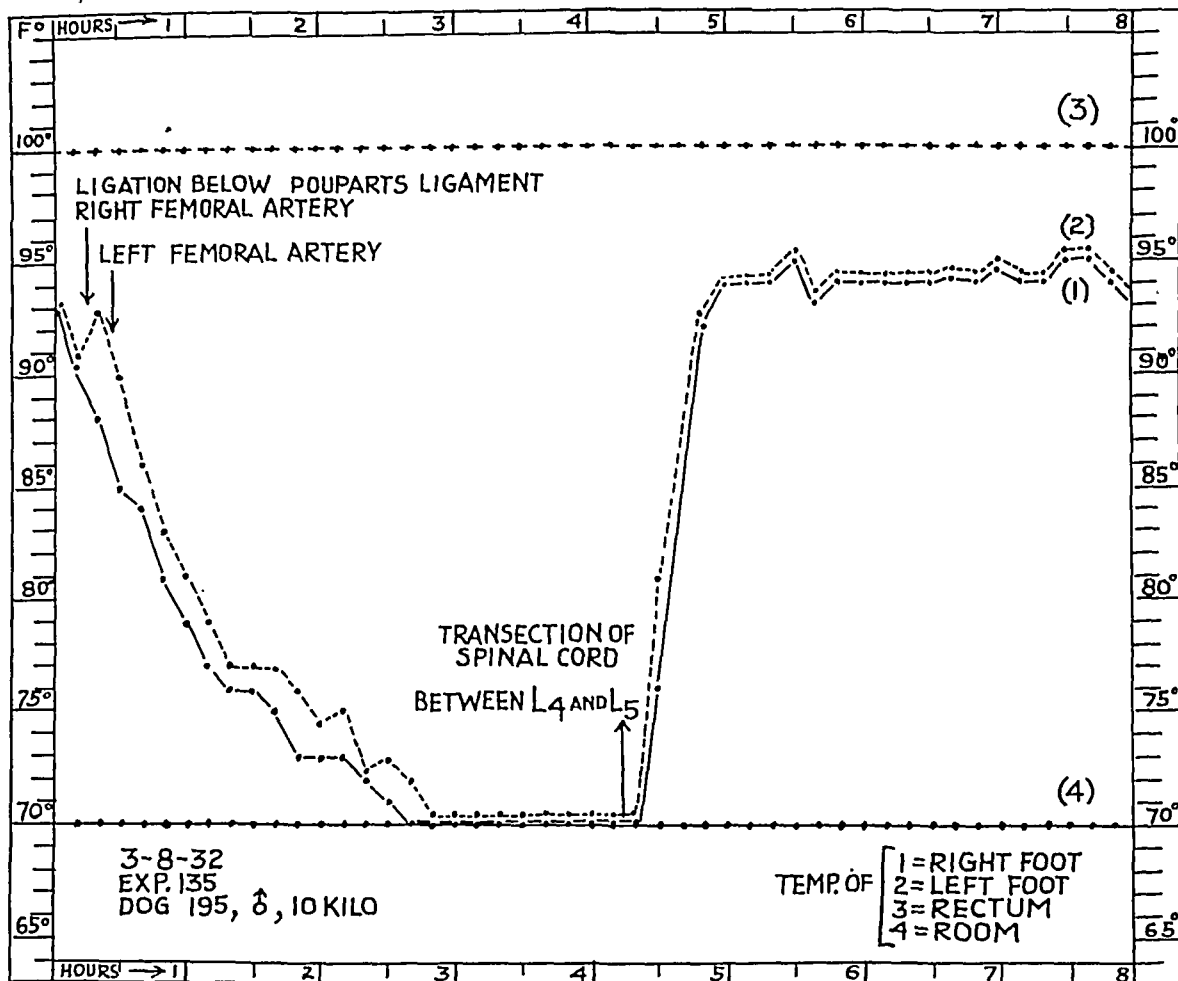


CHART VII.

this if the sciatic nerve was divided (Chart VIII) there resulted an immediate rise in the temperature of the extremity if none had previously taken place or an increase in the temperature when a previous rise had occurred. This indicated that there were

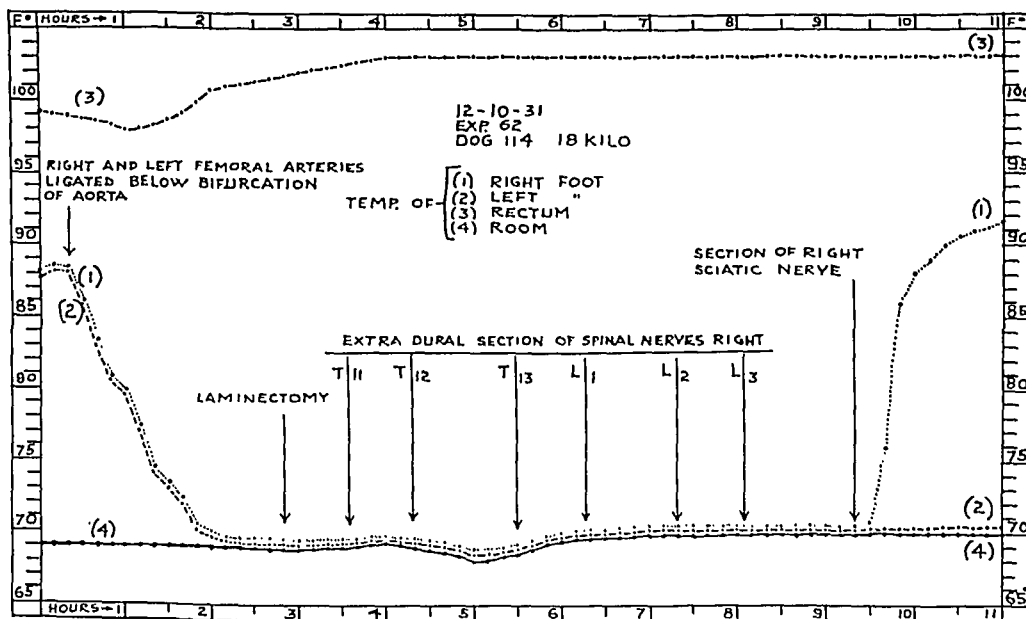


CHART VIII.

vasomotor fibres leaving the cord at levels other than between the eleventh thoracic and third lumbar. A third group of experiments was carried out in which the spinal roots

supplying the sciatic nerve only was sectioned, namely, from the fourth lumbar to the second sacral, and in these experiments also there resulted a rise in the temperature of the extremity. (Chart IX.) These experiments all suggest that there are vasomotor

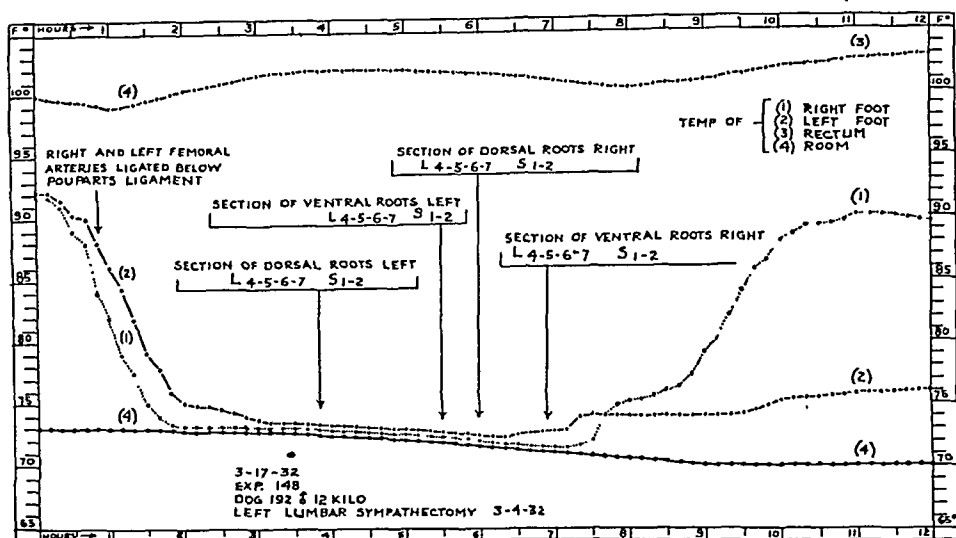


CHART IX.

connector fibres leaving the spinal cord at lower levels than have previously been assumed.

In addition, another group of experiments was designed to study the effect of removing the lumbar sympathetic chain in dogs. (Chart X.) In these experiments the sympathetic chain was extirpated from the level of the second lumbar vertebra to the level of the third or fourth sacral vertebra. Following this there was an immediate

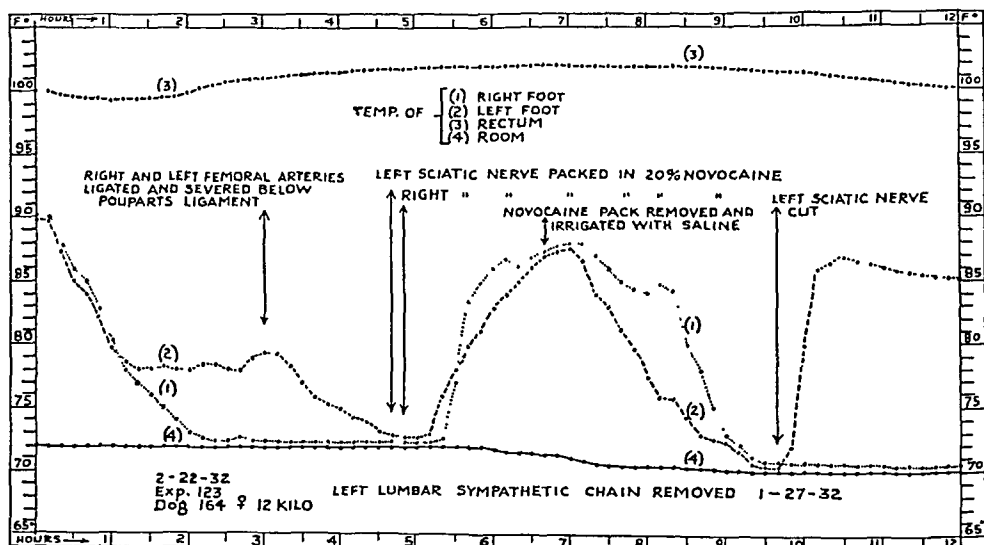


CHART X.

vasodilatation. Temperature studies were carried out over a period of weeks, and in general it was found that this vasodilatation became less and less marked until at a period from two to six weeks following operation the temperature of the sympathectomized limb, when the animal was kept in a constant environment of 70°, was essentially the same as the normal limb. If the sciatic nerve was then packed in novocaine or

sectioned, there was an immediate rise in the temperature of the extremity. In some dogs even at the end of two months there was still a considerable vasodilatation in the sympathectomized limb. In all of the dogs the difference in the two limbs could be demonstrated by differences in response to exercise or rapid temperature changes. Also the degree of response after section of the sciatic nerve varied considerably.

At present we are unable to interpret these findings but they suggest that possibly there are sympathetic vasomotor pathways which do not pass through the paravertebral ganglionic chain.

Summary.—(1) The varied results obtained by operative procedures designed to interrupt sympathetic vasomotor pathways may in part be explained by our lack of knowledge of the exact course pursued by these fibres and particularly the levels at which they leave the spinal cord.

(2) Evidence has been presented which suggests that the connector fibres between the spinal cord and sympathetic chain have much wider distribution than has formerly been supposed.

(3) In view of this fact, it is suggested that operations designed to remove a portion of the sympathetic ganglionic chain should be made even more extensive and particularly in lumbar sympathectomy, the ganglia should be removed to as low as the level of the second sacral vertebra.

BIBLIOGRAPHY

- ¹ Bayliss, W. M., and Bradford, J. R.: The innervation of the vessels of the limbs. *Jr. Physiol.* vol. xxi, pp. 10-22, 1894.
- ² Gaskell, W. H.: The involuntary nervous system. Longmans Green & Co., 1916.
- ³ Langley, J. N.: The autonomic nervous system. Part I. W. Heffer & Sons, 1921.
- ⁴ Langley, J. N.: On the course and connection of the secretory fibers supplying the sweat glands of the feet of the cat. *Jr. Physiol.* vol. xii, pp. 347-374, 1891.
- ⁵ Langley, J. N.: The arrangement of the sympathetic nervous system based chiefly on observations upon pilomotor nerves. *Jr. Physiol.* vol. xv, 1894.

THE QUANTITATIVE DETERMINATION OF VASOCONSTRICTOR SPASM AS A BASIS FOR THERAPY IN PERIPHERAL ARTERIAL DISEASES *

BY JOHN J. MORTON, M.D.

AND

(by invitation) W. J. MERLE SCOTT, M.D.

OF ROCHESTER, N. Y.

THE realization that spasm plays a part in a considerable proportion of the common peripheral arterial diseases made it necessary to develop methods for measuring it. The first attempts were naturally concerned more with the demonstration that vasoconstriction was or was not present in any given case under study. These qualitative tests had a definite place in emphasizing to the profession the importance of spasm in the peripheral arterial diseases.^{1, 2, 3, 4}

The methods generally adopted to bring out the presence or absence of spasm depend upon surface thermometry and tests which free the blood-vessels from the influence of sympathetic vasoconstriction. It was necessary first to develop a convenient and rapidly responding type of surface thermometer. It was also essential to recognize the factors which conditioned the application of this instrument. If the external physical factors could be kept relatively constant, then surface temperature would offer a means of gauging the volume and velocity of the blood flow through the cutaneous areas. All these conditions had been fulfilled by careful investigations in many laboratories.^{5, 6}

It seemed to us to be of the first moment to establish proper normal controls and standards. Accordingly, our original investigations were made upon subjects with normal peripheral blood-vessels. Constant environmental conditions were established and tests gradually evolved which allowed us to record the response of the normal vessels when released from the influence of the sympathetic vasoconstrictors. In this way, the *normal vasodilatation level* was defined. It was recorded as the maximum surface temperatures attained when all sympathetic vasoconstriction had been removed by appropriate measures in the area tested.⁷

The most convenient method for testing that we have found is by conduction nerve block.^{8, 9} The level for conduction block anæsthesia is 30.5° C. (89.9° F.) at a room temperature of 20° C. (68° F.). The importance of establishing the vasodilatation level is apparent. Without it, we have no normal base line or control. With it, we have a mathematically significant figure, so that quantitative estimations are possible, in comparing the response

* Expenses of this investigation were defrayed by a grant from the Fluid Research Fund of the Rockefeller Foundation.

of diseased arteries to that of normal ones. The precautions necessary for obtaining these data have been described in several previous communications.^{8, 9, 10}

The whole problem of diagnosis of peripheral arterial disease resolves itself into a few relatively simple rules and procedures. In the first place, it is necessary to determine whether the complaint is due to a failure of the blood supply. This can be determined by the history and the ordinary methods of physical examination. The signs and symptoms produced by a failing blood supply are those due to ischæmia of the skin or muscles. There will consequently be color changes of pallor, rubor or cyanosis; tinglings, paræsthesias and actual pain; fatigue, cramps in the muscles and intermittent limping; atrophy or hypertrophy of the skin, nails and subcutaneous tissues; and, in late stages, patches of gangrene or complete circulatory failure to a part—massive gangrene.

The next problem is to decide whether the circulatory failure is due to organic occlusion of the main vessels, sympathetic vasoconstriction, or to a combination of the two. This requires special apparatus in the form of a rapidly responding surface thermometer; and a special test to abolish the influence of the sympathetic vasoconstrictors. The lower limits of the normal vasodilatation level serve as a control level which should be reached if the circulatory channels are not occluded. Having once determined that there is an abnormal function of the peripheral arterial vessels, by this test it is possible to decide whether the trouble is due to occlusion, spasm or both. If under these circumstances on paralyzing the sympathetic vasoconstrictors the surface temperatures rise to the normal vasodilatation level, the condition is obviously due only to spasm. If there is little or no rise, the condition is predominantly one of occlusion; and when mixed, the relative proportions of spasm and occlusion can be determined by subtracting the maximum surface temperature rise from the normal vasodilatation level. The number of degrees by which there is failure to reach the normal vasodilatation level is the occlusion index.

Raynaud's disease in its more severe forms appears to offer an exception to this test for distinguishing arterial spasm and occlusion. There is probably a dual control of the spasm in these instances—a local spasm expressed as hypersensitiveness to cold—and the central vasoconstriction.¹¹ Fortunately, these cases offer no difficulty in the application of the test to the common vascular diseases, as the diagnosis in them is easily made by the character of the attacks when they are severe enough to fail to respond to nerve block. The spasm can also be readily abolished under these circumstances by the application of heat.

The following cases will serve to illustrate the value of quantitative pre-operative determinations of vasoconstrictor spasm in individuals with peripheral vascular disease. There is often a problem of surgical judgment even when it is clearly demonstrated that spasm is an important element in the circulatory failure.

CASE I.—F. G., No. 46101, a man, fifty-four years of age, was seen because he had attacks of intermittent claudication, on walking. For several months he had noticed mild pain and cramping in the calves, especially on the right side. This was most prominent when he was exercising or going upgrade. The pain on the right extended as far as the hip and groin at times. Otherwise there were no symptoms. He usually smoked about thirty to forty cigarettes a day. Examination showed an exceptionally well-developed man. The positive findings centred on the peripheral vascular system. The brachial blood-pressure was 124 systolic, 72 diastolic. There were no signs of sclerosis in the vessels though the walls could be palpated. The right foot and ankle were cooler than the left. The right dorsalis pedis and posterior tibial arteries could not be palpated. Even the right femoral and popliteal arteries gave only slight pulsations.

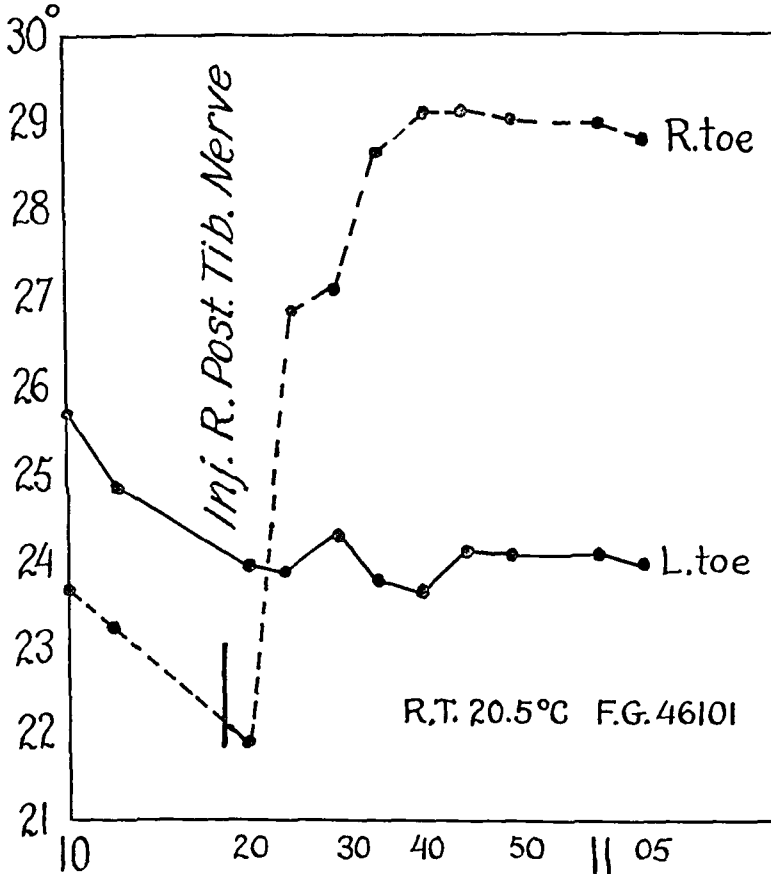


FIG. 1.—(Case I.) Nerve-block anaesthesia demonstrates that the vascular insufficiency is partly due to occlusion but mainly to spasm. The occlusion index is 1.5°C . Lumbar ganglionectomy would undoubtedly improve the circulation in the right foot but the complaint was too slight for the major operation.

Pulsations could easily be made out in all the major arteries of the left lower limb. Röntgen-ray examination of the lower limbs showed no definite evidence of calcification of the arteries. When the right posterior tibial nerve was injected with 1 per cent. procaine, the surface temperatures in the anæsthetic areas showed a prompt rise to 29°C . This indicated an "occlusion index" of 1.5°C . and the presence of a large element of spasm. (Fig. 1.)

The symptoms in this patient were of moderate degree. He could get about for his usual activities without embarrassment. The cramps were brought out only by exceptional activity. Should he be subjected to the

risk of a major operation? Undoubtedly, the peripheral circulation would be improved by such a procedure. The risk of the operation in such a patient should be carefully weighed against the benefit to be obtained. We decided, in this instance, that the symptoms were not sufficiently grave to warrant the procedure. This patient might conceivably go for years without being incapacitated. This type of case makes the surgeon wish that a less extensive operation were available.

The next patient, on the other hand, although urgently in need of relief, presented the opposite picture. Spasm seemed to be largely responsible for his severe claudication. There were many complications, however, which made the ideal treatment too hazardous to be considered.

CASE II.—G. S., No. 52560, a man of seventy years, was admitted to the medical service because of attacks of angina pectoris. In addition he complained of painful cramps in the left leg and foot. Eleven years ago there was a temporary paralysis of one arm. This cleared up rapidly and there were no other symptoms. There had been a non-productive, hacking cough for five years. Four years ago he began to suffer with attacks of paroxysmal tachycardia. These attacks were controlled by pressure over the vagus. Five months ago, there was an attack of difficult breathing and weak, irregular pulse. Digitalis was prescribed. Two months later he had his first attack of anginal pain. There was a sensation of precordial pressure with radiation of pain down both arms. Similar attacks have recurred since, all relieved by nitroglycerine. Three weeks before admission the patient was found unconscious by his wife. He was cold and sweating and had a weak irregular pulse. It was an hour before warmth could be restored to his body. He did not recall the episode on waking, and had a "thick tongue" for some time. He also showed a memory defect as information had to be repeated several times before he understood it. This period passed after a little while and he apparently recovered completely. The painful cramps in the left leg began two years ago. They came only at night, not when he was up on his feet. They started in the second and third toes which flexed under in definite spasms; and spread across the flexor muscles of the foot and up into the calf. The attacks were very frequent and painful with short periods of intermission. They had been relieved by forcible hyperextension of the affected toes; or by hanging the foot over the edge of the bed. Rarely during the two years had he been free from these nightly attacks of cramping. They had often been associated with precordial anginal pain as well. There had been nocturia, once or twice for the last fifteen years. The patient had always been nervous and highstrung and this seemed to aggravate his condition, according to his wife. He appeared on examination to be a senile man who had evidently suffered considerably in recent months. There were râles at both bases posteriorly and an impaired resonance over the whole back. The heart was not enlarged nor irregular in action but an electrocardiogram indicated myocardial damage and right ventricular preponderance. The blood-pressure was only 140 systolic and 80 diastolic. There were no evidences of peripheral arteriosclerosis either by physical examination or by Röntgen-ray studies. The prostate was definitely enlarged with benign hypertrophy of the right lobe. The left posterior tibial nerve was anæsthetized with 1 per cent. procaine. There was a fairly rapid rise in the surface temperatures in the anæsthetic area to the normal vasodilatation level. This indicated that without doubt the major portion of his peripheral vascular complaints was due to overstimulation of the sympathetic vasoconstrictor fibres. (Fig. 2.)

In this old man, with his poor general condition, a left lumbar sympathectomy, although it might give definite relief, would carry a very great

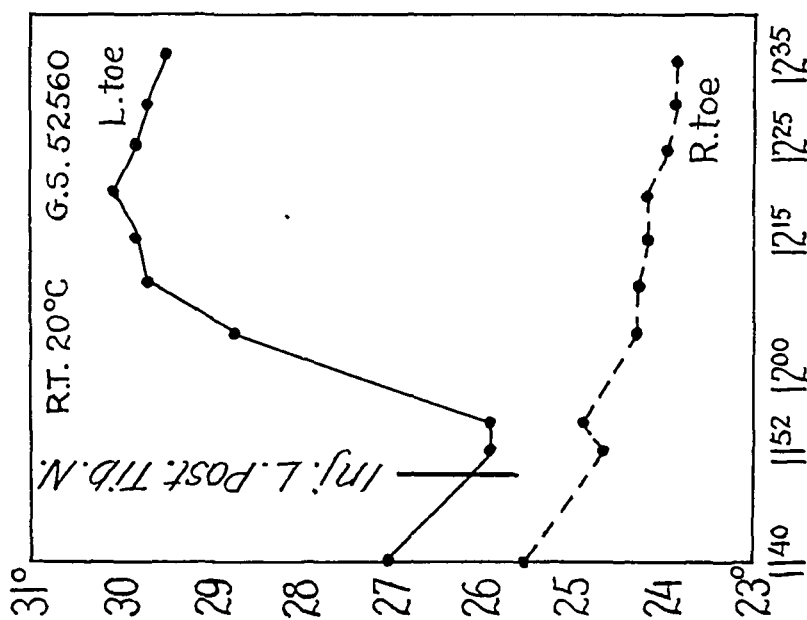


FIG. 2.—(Case II.) The nerve block clearly indicates that the major part of this vascular disease is due to spasm. The rise is to within 0.5° C. of the normal vasodilatation level.

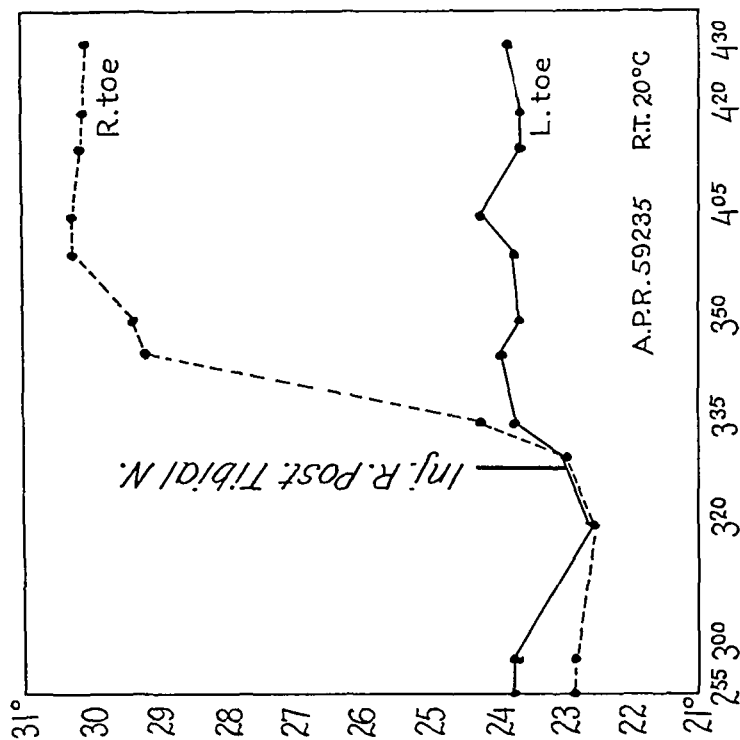


FIG. 3.—(Case III.) Nerve block is followed by a rise in surface temperatures to the normal vasodilatation level. This indicates that spasm is responsible for the vascular deficiency in this case.

risk. In fact, it was considered better judgment to perform no operation in his case. The dangers of myocardial failure, bladder obstruction, hypostatic pneumonia and intracranial hæmorrhage were all only too apparent.

This next patient seemed to be in good general physical condition. His trouble was progressing rapidly, so that he feared total incapacity for carrying on his occupation. The whole situation was frankly discussed with him, and the risks of operation presented. We felt that operation would probably bring him relief. This is one of the border-line cases in which it is extremely difficult to be certain as to the best treatment.

CASE III.—A. R., No. 59235, a man of fifty-nine years, was seen because of increasing claudication in the right leg. He had never had any trouble walking till four months ago. Then he noted a pain in the calf of the right leg when he walked very far. This pain had become more persistent until now he cannot walk a short city block without difficulty. He had always smoked a goodly amount—at least a package of cigarettes a day and frequently one or two cigars as well. On examination the feet were of normal color. There were good pulsations in the left posterior tibial and dorsalis pedis arteries but no pulsation could be determined in the right posterior tibial. The right dorsalis pedis pulsation was present but diminished. Röntgen-ray examination showed slight beading with calcification of the right anterior tibial artery and some calcification over the left popliteal artery. There was very definite calcification in the left dorsalis pedis and posterior tibial arteries. The arteries on the left side seemed to show more calcification than on the right side where the symptoms were noted. Injection of the right posterior tibial nerve with 1 per cent. procaine caused a rise in the surface temperatures to the normal vasodilatation level. It is apparent from this test that there was a marked element of spasm in this picture. (Fig. 3.)

That operation is not without danger is attested by the record of the following patient. He was considered to be urgently in need of operation to preserve a failing circulation. The reaction to the operation was decidedly severe. For almost one week it was doubtful whether he would live. His condition then improved and he was discharged after a slow convalescence. The circulation has improved, but though he has not had claudication in the right leg, there have been small areas of migratory phlebitis.

CASE IV.—C. B., No. 24437, a Jewish man of fifty-one years, was admitted to the hospital in May, 1929. He had been troubled with pain in the calf muscles of the legs for ten years. This pain came on after walking. It had been getting progressively worse during the last two years until now he cannot walk more than 100 feet. The pain, in the nature of a muscle cramp, never came when the patient was at rest. It practically disappeared as soon as he stopped walking. He was an obese, emphysematous type. The heart was not enlarged. The blood-pressure was 164 systolic, 88 diastolic. There was an absence of pulsations in the vessels of the feet and in the popliteal arteries on both sides. The femoral pulsations were easily felt, the right being weaker than the left. When the feet were elevated there was a cadaveric hue and in the dependent position both feet were greatly congested. The tip of the great toe and the second toe of the right foot were a purplish black, much more congested than any other part of the foot. There was no calcification of the arteries by Röntgen-ray. A diagnosis of thromboangiitis obliterans was made. A right lumbar sympathetic ganglionectomy was done through the abdominal approach a few days after admission. Convalescence was stormy and complicated by acute dilatation of the stomach, paralytic ileus, and broncho-

pneumonia. After a critical period of about one week he gradually improved and was discharged about one month after entry.

There was obviously some improvement in the circulation of the right leg following operation, as the surface temperatures were distinctly higher than those on the left. The response was almost to the normal vasodilatation level on the right side. Since operation the function of the right leg has improved, while that of the left leg has become more impaired. He can now walk as far as a quarter of a mile without getting symptoms on the operated side. Claudication is then present on the unoperated side which limits his activity. There is a considerable variation in the condition, at times he is much better than at others. He has had two small areas of tenderness in the right calf which probably represent migratory phlebitis. The right foot remains warm and dry in decided contrast to the cold, damp, cyanosed left extremity. The surface temperature on the right great toe is consistently at 29° C. to 30° C., whereas on the left great toe it is 23° C. to 24° C.

The value of the pre-operative quantitative determinations is well illustrated by this next patient, who gives the average result to be expected after operation. It is usually possible to be certain that the post-operative result will closely correspond to the pre-operative quantitative determination. This has been our experience in the great majority of instances. The post-operative surface temperatures usually record a little higher than the pre-operative nerve-block test, which is to be expected. In working out the nerve-block test we found that it did not give quite as high surface temperature readings as those following spinal or general anæsthesia.

CASE V.—N. C., No. 53998, a Russian Jew, forty-eight years of age, was admitted to the Strong Memorial Hospital in January, 1932. He had been in the hospital a few months previously because of chronic bronchitis, asthma, chronic tonsillitis, and sinusitis. These ailments had followed an attack of typhoid and pneumonia thirty years previously. While he was on the medical service he stated that he had had pain in the calf muscles of the right leg and pain along the right shin bone when he walked about two blocks. He also claimed that his feet became quite cold at times. There had been pain at night in this leg also, and a sense of tiredness in it on exertion.

Examination revealed that the feet were cold and bathed in perspiration. There was no pulsation of the right dorsalis pedis artery made out although the left one had an excellent pulse. Pulsations could be easily demonstrated in the other arteries of the limbs. When the patient was nervous or was in a cold room the right great toe became markedly cyanosed.

When both feet were elevated and the toes exercised, the right great toe showed a cadaveric color. When the feet were dependent there was a cyanosis of this same digit.

Röntgen-rays showed no definite calcification in the walls of the right dorsalis pedis artery but possibly a little evidence of sclerotic changes in the posterior tibial artery.

Examination was negative for diabetes and syphilis.

The right posterior tibial nerve was injected with 1 per cent. novocaine. There was a rapid rise in the temperature in the toes and sole to the normal vasodilatation level. This was interpreted to mean that the circulatory deficiency was on a vasoconstrictor spasm basis. Sympathectomy was advised but refused.

He was discharged from the hospital but when he began to resume his activities he also had trouble in his left leg. Both feet were cold a greater part of the time. The cramps and pains continued if he walked for any distance. He noticed that his toes had a purplish color when the feet hung down. Just above the left ankle, the leg became hot and swollen. He felt a weakness in both legs. He reentered the hospital

VASOCONSTRICTOR SPASM IN ARTERIAL DISEASES

for operation. The only new finding on examination was a reddened area about six centimetres long just above the ankle on the medial aspect of the left lower leg.

A diagnosis of thrombo-angiitis obliterans was made. Right lumbar ganglionectomy was performed through the abdominal approach. The patient had considerable cough following operation but his course was in general satisfactory. There was a decided improvement in the color, warmth and comfort of the right leg immediately following operation. Surface-temperature readings taken about three weeks after operation showed a very close correspondence with the pre-operative quantitative determinations. (Fig. 4.)

In our experience it is not uncommon to find a gradual improvement in the surface-temperature readings as time goes on. This result is possibly to be expected in a good number of these patients. It must represent the opening of collateral channels. This may be an argument also for operation even when there is an occlusion index of several degrees. We have not had enough experience, however, to be certain of this point.

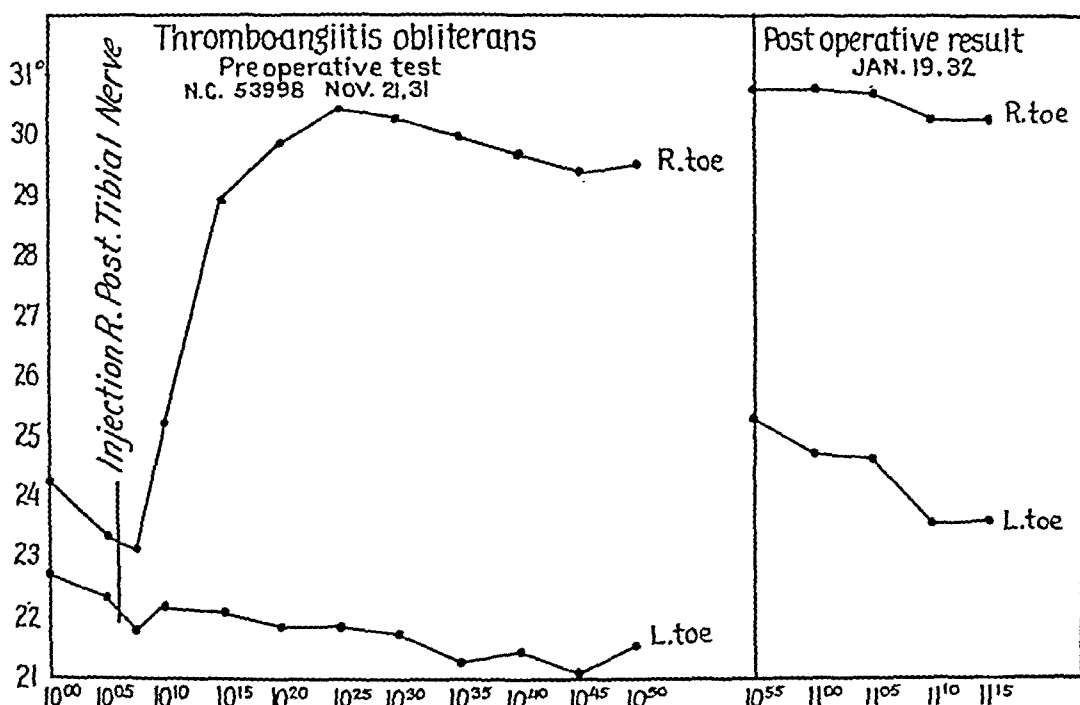


FIG. 4.—(Case V.) The post-operative determination checks almost exactly with the pre-operative quantitative test. This is the average result to be expected.

CASE VI.—P. B., No. 40711, a Russian Jew, thirty-one years of age, was admitted to the hospital on November 6, 1930, because of pain in the right foot. He first began to have sharp shooting pains in the toes of his right foot in September, 1929. The foot was icy cold and white at this time. The pain came on more often when he was on his feet and it continued to grow worse. In January, 1930, the right femoral vein was ligated in another city. The leg swelled up greatly following this and the foot became a dusky purple in color. The pain, however, was relieved until four to five days prior to entry. He was a well-developed man. The main interest in the examination was in the lower extremities. There was marked swelling of the toes and dorsum of the right foot. In the dependent position this foot became plum colored. There were bronzed streaks over some of the superficial veins indicating an old thrombo-phlebitic process. Both popliteal arteries gave good pulsations but on the right side only a very faint pulsation could be made out in the dorsalis pedis artery and no certain pulsation in the posterior tibial artery. The pulsation was excellent in the left posterior tibial artery and fair in the dorsalis pedis artery, though at times difficult to palpate.

A vasomotor test under nitrous oxide-ether anaesthesia gave evidence of a large element of spasm, the surface temperature rising to 30° on the right great toe in contrast to a rise to 32° on the left great toe. Röntgen-ray examination showed no evidence of calcification of the arteries. A diagnosis of thrombo-angiitis obliterans was made. Right lumbar ganglionectomy was done by the anterior intra-abdominal route.

The operation was well borne and the immediate effects on the circulation of the right foot were almost as prognosticated from the preliminary tests. The oedema and cyanosis were absent and the right foot remained of good color on discharge from the hospital. The surface-temperature readings on the right great toe one month after operation were 28° C. and 29° C. as against the readings of 23° C.- 24° C. for the left big toe. The swelling was gone and the color better except in the dependent position, when it still assumed a purplish hue. Five months after operation he had a dull constant pain under the left great toe. The skin over this area was swollen, bluish and tender. Eleven months after operation his right foot remained warm, pink and dry, whereas the left foot was covered with perspiration, was several degrees colder and the toes were whiter than those on the right. There was also a slightly tender, subcutaneous mass on

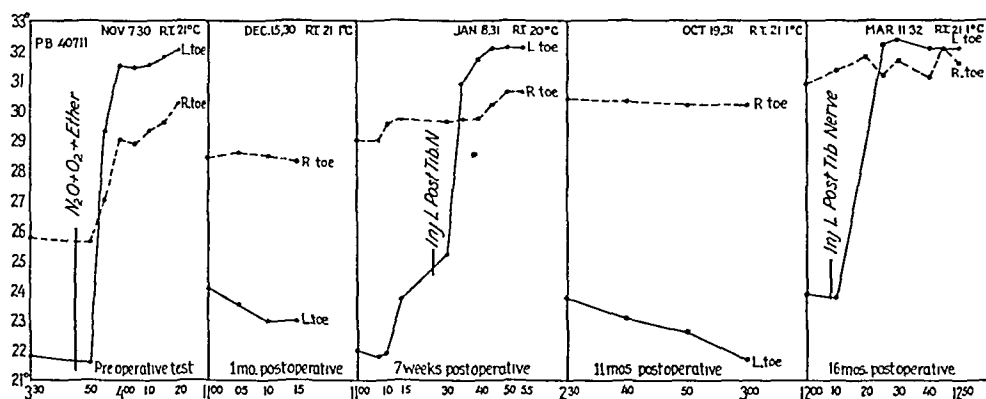


FIG. 5.—(Case VI.) The immediate result (one month following operation) did not appear to be as good as the pre-operative determination indicated. There has been a slow but steady improvement as time goes on. The big toe appears to have reestablished an adequate circulation by the development of collateral circulation.

the right leg just above the ankle. This probably represented thrombosed veins, another evidence of migratory phlebitis still occurring even in the sympathectomized area. Sixteen months after operation the surface-temperature readings on the sympathectomized limb were at the normal vasodilatation level. There has been a slow but steady improvement in the surface temperatures over a long time. This seems to point to the establishment of better collateral circulation. (Fig. 5.)

An unusual but gratifying result is occasionally observed when there is an immediate post-operative improvement better than the quantitative pre-operative test would lead us to look for. This unexpected improvement occurs only in small patches and is not a general phenomenon over the whole denervated area. It must not be counted upon as there is no way to predict when it will occur. Fig. 6 shows the progressive improvement in two small areas. It brings out also very well that the initial temperature readings may be widely separated, varying in their height with uncontrollable psychic factors. The patient should be left exposed for at least an hour according to Benedict⁶ in order for the surface temperatures to reach stability. This has not been practical but we have adopted a half-hour period at constant temperature conditions before making readings, in this way getting at least

the trend of the temperature curves. The first part of the chart shows that sympathetic vasoconstriction was prominent on both sides. The patient did not know what to expect. He had been told that he would have a test for his arteries. He was wheeled to the windowless, constant-temperature room where his feet were exposed for one hour. During this time the temperatures progressively dropped (not shown in the chart) probably through psychic upset in regard to what was in store for him. When the nerve had been injected there was a good anæsthesia obtained over its whole distribution and in other areas tested vasoconstriction was almost abolished, the surface temperatures reaching 29° C. to 30° C. These areas are not included in the chart in order to simplify its interpretation. The fact that anæsthesia was obtained and that other areas showed release from vasoconstriction should dispose of the possible objection that the test was inadequate. In the second part of this figure, the patient knew what it meant to have readings done. It was with a different outlook that he approached this trial and he displayed in consequence little vasoconstriction even on the unoperated side. The improvement in surface-temperature readings in the two small areas was decided. It can best be judged by the nearness to the vasodilatation level, 30.5° C., and not by the relation to the starting point. This is the importance and significant reading. The other areas on the operated side recorded temperatures almost identical with the pre-operative quantitative determinations. The third part of the chart shows a still greater improvement and a wider separation between the readings on the operated and unoperated sides. The toe and sole on the operated side now come into the limits of the vasodilatation level. This can only mean a reëstablishment of collateral circulation or a canalization of the occluded main vessels, more likely the former.

CASE VII.—W. R., No. 56630, a Russian Jew, fifty-six years of age, was admitted to the Strong Memorial Hospital on January 21, 1932. One year ago he began to have pain in his left great toe. This toe became inflamed and in three weeks it assumed a brownish-black color. He went to a hospital where he was put to bed for about eight weeks during which time the toe gradually lost some of its blackness. He then began to experience a dull continuous pain in his left heel and arch; and after that pain of the same general character in his left thigh. He had spent a great deal of his time in bed since this experience as he was much afraid of aggravating the condition. He had always been a heavy smoker. He had upon examination a chronic bronchitis and no other abnormalities except for his local condition. There was an obvious disease of the arteries of the left leg. The toes on this side showed an atrophy of the subcutaneous tissues and a thinning of the skin. Just behind the medial surface of the left great toenail there was a small area where there had been an ulcerated lesion. The epithelium had not quite covered this area. In the dependent position of the left foot, there was rubor and upon elevation the toes became white after exercise. The left dorsalis pedis pulsation could be felt but it was very small. The posterior tibial pulsation was fair but of much smaller volume than the right posterior tibial pulsation. The left popliteal pulsation was not easily felt. All pulsations on the right were good except the dorsalis pedis, which was only fair. There was no calcification of the vessels by Röntgen-ray. There was no evidence of syphilis or diabetes.

Anæsthesia of the left posterior tibial nerve was carried out. It showed a good rise in the heel and sole and a delayed and incomplete rise in the toes. The temperature of the great toe reached only 26.5°C ., an indication of a considerable degree of occlusion to the blood supply. A diagnosis of thrombo-angiitis obliterans was made. A left lumbar ganglionectomy was done by the anterior abdominal approach. The post-operative recovery was satisfactory. There was a decided improvement over the pre-operative determinations almost immediately following operation. The surface temperatures recorded within two weeks indicated a greater improvement than had been looked for in certain small areas—the great toe and parts of the sole. This could be explained only by the general improvement in the collateral circulation immediately adjacent to these areas and the opening up of new channels in the areas themselves.

Two months after operation the left foot was warmer than the right. (Fig. 6.) In the dependent position there was still decided rubor of the great toe. There was relief

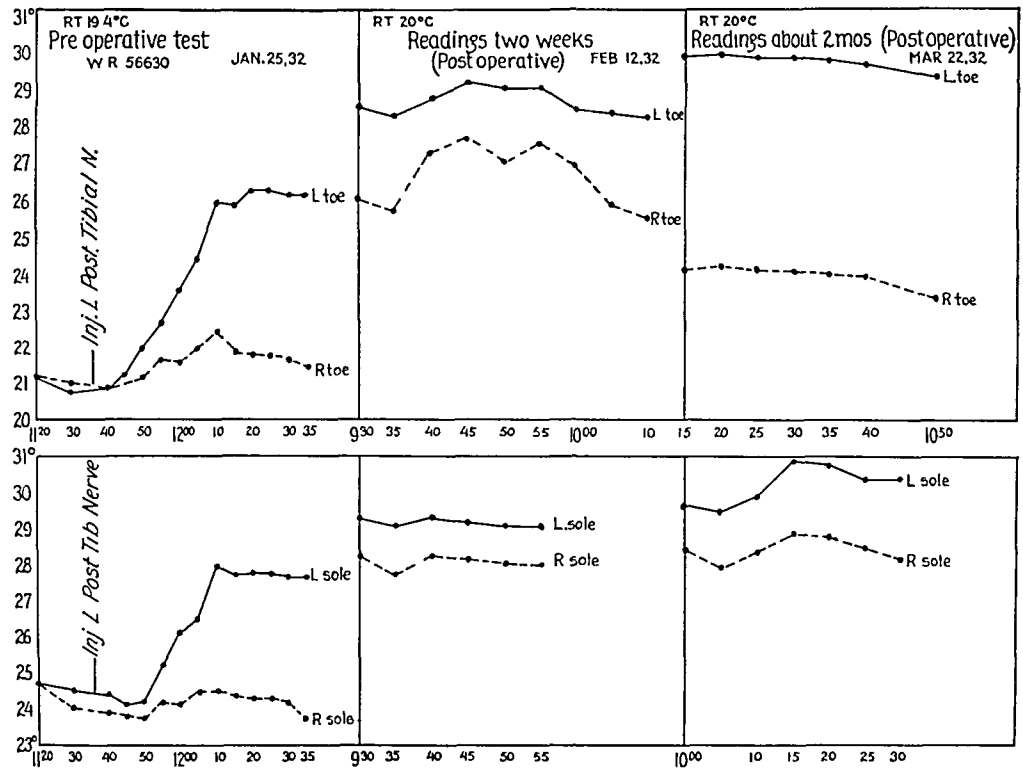


FIG. 6.—(Case VII.) This chart is more fully explained in the text. The records have been abbreviated to save space. There should be a thirty-minute control period before readings have any significance. These charts illustrate the importance of the vasodilatation level as compared to the rise from a starting point. The nearness to 30.5°C . is much more significant. There has been a rapid progressive improvement in small areas in this case.

from the burning pain in his toes, and the claudication in this limb had disappeared. Surface-temperature readings demonstrated a progressive improvement in the circulation through the subpapillary network. This collateral circulation had apparently responded to the removal of sympathetic influences and the surface temperatures were in the normal zone at the vasodilatation level. The left foot was in excellent condition four months after operation. The ulceration had completely healed and the foot was warm.

The importance of the collateral circulation in any type of peripheral ischæmia whether due to occlusion or spasm cannot be overemphasized. This has been recognized by the great master surgeons since the time of Hunter. Halsted and Matas repeatedly have called attention to the significance of

developing collaterals in diseases of the arteries. Treatment has been of benefit in proportion to the success in dilating these channels. Most of the measures advocated for relief of the peripheral arterial disorders have as their ultimate object the stimulation of a sufficient collateral network to keep the tissues viable. Lewis and Reichert,¹² recognizing this principle, went so far as to ligate the main arterial channels in thrombo-angiitis obliterans. Sympathetic ganglionectomy affords the most continuous permanent dilatation of the collateral circulation of any method yet proposed. The pre-operative quantitative tests which we have sponsored give a fairly accurate estimate of the results to be expected following removal of the sympathetic vasoconstrictors. The gradual general improvement with time, and the unusual immediate striking improvement in small areas in some cases, must be taken as indications of improved collateral circulation.

CONCLUSIONS.—In actual practice, the immediate results achieved by sympathectomy generally correspond quite accurately to the pre-operative quantitative determinations.

The immediate post-operative improvement in claudication is usually striking.

In some instances, the immediate post-operative results as measured by surface-temperature readings are better than the pre-operative determinations. This immediate improvement is usually confined to small areas and is not a widespread reaction.

Late post-operative results frequently demonstrate a slight general improvement in surface-temperature readings over the pre-operative determinations. This is undoubtedly dependent on an improved collateral circulation.

In thrombo-angiitis obliterans sympathetic ganglionectomy does not give assurance of freedom from a continuation of attacks of migratory phlebitis. In our series recurring phlebitis has been noted fairly often in the sympathectomized areas. These episodes are usually self-limited with spontaneous remission of acute symptoms. An occasional conservative amputation of a digit becomes necessary when gangrene supervenes. It is our impression that under these circumstances the local amputation can be carried out with more assurance that it will be successful, and that re-amputation will not be necessary. The improvement in collateral circulation to the adjacent areas following sympathectomy is probably responsible.

In any given case the actual or potential disability should be balanced against the risk and promise of the operation.

Both lumbar and cervical sympathectomy are major operative procedures which should not be undertaken without strong indications for their use.

In individuals beyond fifty years of age who complain of only slight degrees of claudication, and who exhibit neither severe pain nor impending gangrene, we advise against operation as being too radical.

In individuals with only occasional attacks of arterial spasm, relieved by heat, we believe that the risk of operation outweighs the disability. Conse-

quently, we are very conservative in operating on the usual examples of Raynaud's disease.

In dealing with the purely occlusive types of arterial disease, the treatment adopted in our clinic has been recently outlined by Pearse.¹³

BIBLIOGRAPHY

- ¹ Brown, G. E.: The Treatment of Peripheral Vascular Disturbances of the Extremities. Jour. Am. Med. Assn., vol. lxxxvii, p. 379, 1926.
- ² White, J. C.: Diagnostic Blocking of Sympathetic Nerves to Extremities with Procaine. Jour. Am. Med. Assn., vol. xciv, p. 1382, 1930.
- ³ Brill, S., and Lawrence, L. B.: Changes in Temperature of the Lower Extremities Following the Induction of Spinal Anæsthesia. Proc. Soc. Exper. Biol. and Med., vol. xxvii, p. 728, 1930.
- ⁴ Ipsen, Johs: Recherches sur les arteres a l'etat pathologique. Acta Chir. Scandinavica, vol. lxxv, p. 341, 1929.
- ⁵ Brooks, B., and Jostes, F. A.: A Clinical Study of Diseases of the Circulation of the Extremities; A Description of a New Method of Examination. Arch. Surg., vol. ix, p. 485, 1924.
- ⁶ Benedict, F. G., Miles, W. R., and Johnson, A.: The Temperature of the Human Skin. Proc. Nat. Acad. Sc., vol. v, p. 218, 1919.
- ⁷ Morton, J. J., and Scott, W. J. Merle: The Measurement of Sympathetic Vasoconstrictor Activity in the Lower Extremities. Jour. Clin. Invest., vol. ix, p. 235, 1930.
- ⁸ Morton, J. J., and Scott, W. J. Merle: Methods for Estimating the Degree of Sympathetic Vasoconstrictor in Peripheral Vascular Diseases. New Eng. Jour. Med., vol. cciv, p. 955, 1931.
- ⁹ Scott, W. J. Merle, and Morton, J. J.: The Differentiation of Peripheral Arterial Spasm and Occlusion in Ambulatory Patients. Jour. Am. Med. Assn., vol. xcvi, p. 1212, 1931.
- ¹⁰ Scott, W. J. Merle, and Morton, J. J.: Sympathetic Activity in Certain Diseases, Especially Those of the Peripheral Circulation. Arch. Int. Med., vol. xlviii, p. 1065, 1931.
- ¹¹ Morton, J. J., and Scott, W. J. Merle: Some Angiospastic Syndromes in the Extremities. ANNALS OF SURGERY, vol. xciv, p. 839, 1931.
- ¹² Lewis, Dean, and Reichert, F. L.: The Collateral Circulation in Thrombo-angiitis Obliterans. An Indication for Ligation of the Femoral Artery Just Distal to the Profunda. Jour. Am. Med. Assn., vol. lxxxvii, p. 302, 1926.
- ¹³ Pearse, H. E., Jr.: The Use of Vein Ligation in the Treatment of Arteriosclerotic and Diabetic Gangrene. Jour. Am. Med. Assn., vol. xcvi, p. 866, 1932.

SURGICAL TREATMENT OF CERTAIN VASCULAR DISORDERS BY SYMPATHECTOMY

BY DAVID E. ROBERTSON, M.D.

OF TORONTO, CANADA

It is becoming increasingly more evident that the clinical result in the treatment of Raynaud's disease by sympathectomy has not borne out the supposition that Raynaud's disease is due solely to spasm of the arterioles under the control of the sympathetic nerves. Claud Bernard's discoveries of the vasoconstrictor fibres in the sympathetic nerves have been proved. It has been proved also that sympathetic fibres are part of a mixed and sensory nerve. It is not now generally believed that the course of the sympathetic nerves runs any considerable distance in the walls of the vessels, not far enough at all events to be a factor in the consideration of these vascular diseases. Jaboulay, and later Leriche, exploited the periarterial vascular sympathectomy, and there are many cases recorded in the literature whose clinical results have been satisfactory following this procedure.

Braeucker¹ believes that: "Vasomotor tracts of the upper extremities have at the beginning the same course as the secretory tracts and reach the first thoracic and the inferior cervical ganglia. A row of fine branches goes from the ganglion to the sub-clavian artery and vein and wraps around the vessels forming a large irregular nerve plexus, and proceeding in their course with the blood-vessels. The largest mass of vasomotor fibres pass over the rami communicantes into the roots of the brachial plexus and run with it distally. From the spinal nerves small branches pass to the blood-vessels which enter the perivascular nerve plexus, increase and renew it, and carry this net formation to the periphery. The perivascular nerve plexus at the inferior cervical ganglion is formed from direct branches of the sympathetic, but the entire nerve plexus of the peripheral vascular structure is formed from indirect branches, from the sympathetic over the rami communicantes and the spinal nerves. The vasomotor fibres, therefore, enter the perivascular nerve net through two roots: (1) Direct, from the sympathetic; (2) indirect, from the sympathetic over the rami communicantes and the spinal nerves. The direct sympathetic branches form the perivascular net in the neighborhood of the sympathetic, and the indirect in all peripheral vascular areas, and the resulting plexus of both is continuous. The perivascular nerve net is a special apparatus which may live and function independent of the centres."

Foerster² reported a case of traumatic section of the brachial plexus distal to the rami communicantes. According to Langley, in the sectioned spinal nerve a degeneration of the spinal and vasomotor elements should have developed, but when he stimulated the digital artery there was severe pain. The nerve plexus of the distal vascular parts was not degenerated, although it was cut from its centre, and there was present an afferent tract in the perivascular net. The vascular net, therefore, remains intact after section of the rami communicantes.

That arteriospasm could be relieved by division of the appropriate sympathetic trunks: Kuntz,³ in speaking of the sympathetic control of the vessels of the upper extremities, stated that complete sympathetic denervation of the upper extremity requires extirpation of the stellate ganglion and of the upper portion of the thoracic sympathetic trunk to the level below the communicating rami of the second thoracic nerve, or section

of the second thoracic nerve and peripheral rami arising from the thoracic sympathetic trunk above this level, in addition to section of the gray rami connecting the stellate and middle cervical ganglion with the brachial plexus.

Adson and Brown⁴ state: "The strikingly maintained and unequivocal therapeutic effects of the lumbar and dorsal sympathetic ganglionectomy in Raynaud's disease seem to warrant the belief that surgical control in this disease is an accomplished fact."

Davis and Kanavel⁵ describe a case of a patient who had Raynaud's disease. A right cervical sympathetic chain was removed. There was a prompt improvement in the right upper extremity. Within nine days immersion of the hands in cold water produced shortly afterwards a characteristic change.

Adson and Brown speak of failures in the upper extremities following cervical sympathectomy, but are expectant that division below the second thoracic ganglion would, according to Kuntz's theory, relieve spasm in the distal artery.

Lewis⁶ believes an essential factor is present in the peripheral vessel. He finds also that in cases of cervical sympathectomy, digital arteries are expanded by warmth and constricted by cold when innervation has been lost. He says that spasm of the digital vessels may be produced in Raynaud's disease by local cold after division of the sympathetic cord below the second dorsal ganglion and extirpation of this and the inferior cervical ganglion. *The spasm of the vessels in this malady is not due to abnormal vasomotor impulse.*

Morton and Scott⁷ say: "*The essential defect is a hypersensitiveness of the peripheral vessels to cold.* But the vasoconstrictor influences are powerful in bringing on and keeping up attacks, and their removal may be effective in prevention.

Spurling⁸ reports that three typical cases of Raynaud's disease treated by sympathetic ganglionectomy had relief in the upper extremities, but for a period of six to eight months only. *In one case, a combination of trunk resection plus periarterial sympathectomy of the axillary artery failed to effect a cure.*

In a case reported by the writer,⁹ about seven months after bilateral excision of the second thoracic and stellate ganglia, the result seemed all that was to be desired. The immediate improvement in color, increase in temperature and dryness of the skin, together with the very rapid disappearance of the beginning ulceration of the tips of two fingers made it obvious that the blood supply was materially improved; and over a period of months, during which warm weather came, the patient had no further experiences of the symptoms present prior to the operation. With the return of cold weather, and following an upset due to an experience of sudden alarm and fear, she again displayed characteristic symptoms, and during the ensuing winter her disease was definitely marked. She has been able to follow steady employment as a typist, but exposures of her hands to cold have caused her typical attacks. The immersion of her hands into water of 60° F. would be followed in a period of five to ten minutes by the characteristic changes. She states that sudden fear will cause her hands to change at once to a deep plum color. Physical influences, as cold to the hands, produce in her all the symptoms of an attack.

The lower extremities of this patient were greatly improved by lumbar ganglionectomies, done ten days after the cervical ones, and have remained well, being dry, warm and of a good color, without any local attacks during the entire winter.

It may be argued that the ganglia removed did not remove all the sympathetic fibres to the brachial plexus or that there is some other route of the fibres. The fact does, however, remain that by no method have severe cases of Raynaud's disease in the upper extremity been cured by the removal of sympathetic ganglia or nerves. Sympathectomies of a trunk ganglion or periarterial net do invariably produce some improvement, generally a dramatic one. But a return of symptoms after a period of months makes

SYMPATHECTOMY FOR VASCULAR DISORDERS

it appear that there is either an unknown course of vasoconstrictor nerves or an inherent property of peripheral vessels to contract to the irritation of appropriate stimuli. If it is the latter it is difficult to explain why patients should be well and free of attacks for months following sympathectomy, nor does it help us to understand the invariable good results on the lower extremities following lumbar ganglionectomy.

Thrombo-angiitis Obliterans.—The treatment of this disease has in the past been uniformly unsuccessful in preventing, in certain cases, a progressive gangrene. In other cases there has been an arrest of the disease after a marked progression has been made. The severe cases have eventually come to amputation. Nothing surgery has had to offer has seemed of any real hope in arresting the disease.

In this disease there is a tremendously wide field for the application of surgery of the sympathetic nervous system. One may in any particular case test out by some suitable method the improvement in circulation following the temporary paralyzing of the vasomotor fibres going to an extremity. Those cases that are clinically well advanced, having a marked degree of phlebitis, do not react well with an increased circulation following either tests or operation. Early cases of this disease, however, do in nearly every instance show marked response to interference with the vasoconstrictor impulses. While this disease is in so far as is known a primary fault in the vessel wall, yet there is in every case a variable element of spasm, and during the time when important peripheral vessels are obstructed, or nearly so, an increase in the calibre of the vessels concerned in the compensatory circulation is of great natural benefit. A sympathectomy in thrombo-angiitis obliterans, in addition to increasing the blood supply and drying the limb by paralyzing the sweat glands, relieves the pain. This is an outstanding feature following operation. Whether the pain is relieved as the result of release of the vessel spasm or from a direct increased blood supply and the relief of an ischæmia it is impossible to say. Spasm of veins, as is sometimes experienced in recipients of transfusions, is a most painful experience. In Toronto a large number of cases of thrombo-angiitis obliterans have been treated by sympathectomy and as a result it is fair to say that the subjects have been well satisfied. The pain is often completely cured and pulsations that were formerly absent are found in many cases to have returned. Clinically one would think that cold was almost as great a factor in producing attacks in this disease as in Raynaud's disease.

Arteriosclerosis.—A condition such as arteriosclerosis is by no means limited to a certain part or extremity. It occurs in a person who is aging or aged and as it advances is found in some instances to involve the vessels of an extremity to such an extent that the circulation is seriously impaired. This type of case is in certain individuals amenable to treatment by lumbar sympathectomy. Testing of the case will give an idea as to the degree of vascular improvement consequent upon the cutting off of the sympathetic influence. It will be found to produce some effect and in cases of the disease

that are not too far advanced to have already serious reduction in blood supply to the foot a sympathectomy will be a satisfactory proceeding. In a case reported by the writer, a year and a half have elapsed since his operation, prior to which he was confined to bed for pain and impending gangrene of his feet. He was seventy years of age. Following a double lumbar sympathectomy no more opiate was administered. The pain left entirely and the blood supply increased to an obvious degree. He has resumed his normal life and continues well.

Sympathectomies have become a very common operation in Toronto, and it may be said in this connection that, of the 200 reported from three hospitals, there have been no immediate fatalities. Those that have occurred, two in number, were in persons markedly debilitated. In persons in fair health the operation is singularly free from any shock or untoward complications.

BIBLIOGRAPHY

- ¹ Braeucker: Arch. Neurol. and Psychiat., vol. xxii, p. 410, 1929.
- ² Foerster: Arch. Neurol. and Psychiat., vol. xxii, p. 411, 1929.
- ³ Kuntz: Arch. Surg., vol. xv, p. 871, 1927.
- ⁴ Adson, and Brown: Surg., Gynec. and Obst., vol. xlviii, p. 5, May, 1929.
- ⁵ Davis, and Kanavel: Surg., Gynec. and Obst., vol. xlii, p. 6, June, 1926.
- ⁶ Lewis: Heart, p. 75, 1929-1931.
- ⁷ Morton, and Scott: ANNALS OF SURGERY, vol. xciv, p. 5, November, 1931.
- ⁸ Spurling: Surg., Gynec. and Obst., vol. liv, p. 3, March, 1932.
- ⁹ Robertson, D. E.: Jour. Bone and Joint Surg., vol. xiv, p. 57, January, 1932.

RAYNAUD'S DISEASE, THROMBO-ANGIITIS OBLITERANS
AND SCLERODERMA: SELECTION OF CASES FOR AND
RESULTS OF SYMPATHETIC GANGLIONECTOMY
AND TRUNK RESECTION

BY WILLIAM J. MAYO, M.D.

AND

ALFRED W. ADSON, M.D.

OF ROCHESTER, MINN.

THE etiology of numerous diseases is becoming known as knowledge increases concerning the anatomy and physiology of the autonomic nervous system.²⁶ The altered function of this nervous system is not only responsible for certain diseases but undoubtedly determines the course of many other diseases since it influences blood flow, smooth muscle activity, glandular activity and carries afferent pain fibres.

Progress has been made in performing sympathectomy in cases of angina pectoris, congenital hypertrophic dilatation of the colon, cord bladder, spastic trophic and painful lesions of the extremities, and in selected cases of arthritis. The most satisfactory results have been accomplished by sympathetic ganglionectomy and trunk resection in the treatment of peripheral vascular diseases such as Raynaud's disease, thrombo-angiitis obliterans with vasomotor spasm of the collateral and nonoccluded arteries and acral scleroderma following Raynaud's disease. This study will contain a review of our experiences in the treatment of peripheral vascular diseases by sympathetic ganglionectomy and trunk resection.

Anatomy.—The sympathetic nervous system is an aggregation of ganglia, nerves, and plexuses through which the viscera, glands, heart, blood-vessels, and smooth muscles in other situations receive their innervation. The most conspicuous feature of the system is a pair of ganglionated nerve cords, or sympathetic trunks, which extend vertically through the neck, thorax, and abdomen. Each sympathetic trunk is composed of a series of ganglia bound together by short nerve strands. Every spinal nerve is connected with the sympathetic trunk of its own side by one or more gray rami communicantes through which it receives sympathetic fibres for the control of blood-vessels, sweat glands and smooth muscles of the hair follicles situated within the territory of its distribution. The majority of the nerve fibres that take origin in the ganglia of the sympathetic chain are distributed through the gray rami and the spinal nerves.

The thoracic and upper lumbar nerves are connected with the sympathetic chain by white as well as gray rami communicantes. These white rami contain both afferent and efferent fibres. The latter take origin from cells in the gray matter of the spinal cord, travel through the ventral root and white rami, and enter the sympathetic system to terminate in synaptic relation with the nerve cells found in the sympathetic ganglion. They are often designated as pre-ganglionic fibers, whereas those that arise in the ganglia and relay the impulses onward are called post-ganglionic. The gray rami contain post-ganglionic fibres and the white rami contain pre-ganglionic fibres.

The majority of the pre-ganglionic fibres turn either upward or downward in the

sympathetic chain, and run for varying distances within it before ending in its ganglia. The cervical sympathetic trunk is composed exclusively of pre-ganglionic efferent fibres, derived through the white rami from the upper thoracic nerves and ascending to terminate in the cervical sympathetic ganglia. The lumbar and sacral portions of the trunk are composed in the major part of descending fibres derived through the white rami from the lower thoracic and upper two lumbar spinal nerves.

Those fibres of the white rami which are concerned with the innervation of the abdominal viscera pass into the splanchnic nerves and end in the celiac ganglion. These fibres reach the splanchnic nerves after passing through the lower half of the thoracic sympathetic chain but they are not interrupted in the chain ganglia through which they pass. These fibres reach the viscera by following the arterial supply to these organs or by direct extension as post-ganglionic fibres from their various plexiform arrangements or sympathetic ganglion. The thoracic viscera receive their post-ganglionic sympathetic rami from the upper thoracic sympathetic chain in a similar arrangement.

The autonomic nervous system, in addition to the sympathetic thoracolumbar outflow, contains two streams of pre-ganglionic visceral efferent fibres called the parasympathetic system: the cranial stream arises from the third, seventh, ninth and tenth cranial nerves, the sacral stream from the second, third and fourth sacral nerves.

According to Ranson²⁹ and Kuntz²³ most of the sympathetic nerves contain, in addition to the fibres already considered, sensory fibres, which convey impulses from the viscera to the spinal cord. These sensory fibres have their cells of origin in the spinal ganglion and reach the sympathetic system by way of the white rami. Visceral reflexes therefore travel arcs of at least three neurons each. The impulses reach the spinal cord along visceral afferent fibres through white rami and the dorsal roots. These afferent sympathetic fibres end in sympathetic ganglia, and the impulses which they carry are relayed to involuntary muscle and glandular tissue by post-ganglionic fibres. The ganglia of the sympathetic trunk do not serve as reflex centres, but only as relay stations²⁷ in the conduction pathways from the spinal cord to the viscera.

The vasomotor innervation of the arteries of the extremities was once believed to be centrifugal²⁵ in its arrangement, but the work of Kramer and Todd,²² and Potts²⁸ has proved rather conclusively that the distribution corresponds to the musculocutaneous somatic distribution, except for short distances where the principal arteries leave the aorta. Therefore, it is apparent that complete vasodilating effects are accomplished only when all vasomotor fibres are interrupted by section of a sympathetic trunk, by ganglionectomy or by complete ramisection.

Historical Data.—Surgical procedures performed on the sympathetic nervous system date back to 1899, when Jaboulay²⁰ attempted to relieve painful conditions of the lower extremities by performing periarterial sympathectomy. This procedure was not given serious consideration until Leriche²⁴ reported his experiences in 1913, when he advocated periarterial sympathectomy for numerous peripheral vascular, trophic and painful lesions.

Royle,³⁰ in 1924, advocated and performed ramisection for relief of spasticity of the muscles of the extremities, but difficulty was encountered in duplicating his results. Adson has obtained some reduction of the spasticity by abdominal transperitoneal lumbar sympathetic ganglionectomy and trunk resection, which he first performed May 20, 1924. However, he is inclined to believe the results are due to the increased blood supply following thorough interruption of vasomotor fibres, rather than to section of sympathetic nerves to striated muscle, for numerous investigators doubt the existence of sympathetic innervation of striated muscle in mammals. Orbeli²⁷ believes that the sympathetic fibres augment cerebrospinal responses. Von Gaza,²⁹ in 1924, Archibald,⁹ in 1928, and Scrimger,³¹ in 1929, performed paravertebral ramisection of the splanchnic nerve for visceral pain, with some success. This problem is undergoing much investigation at this time.

Adson,³ and Davis and Kanavel¹⁸ were among those who attempted to duplicate

the results of Royle reported in 1924. May 20, 1924, Adson employed the method mentioned in the preceding paragraph, and it was following this that he observed that the temperature of the skin of the lower extremities remained permanently increased. Royle reported that cutaneous temperatures in the first case in which he performed ramisection remained only temporarily increased, but later stated that a slight increase remained permanently. This suggested that the more extensive operation of ganglionectomy and trunk resection included all of the vasomotor fibres to the extremities. This phenomenon reopened the field of surgical treatment of peripheral vascular diseases. Davis and Kanavel, and Diez¹⁷ and Fulton¹⁸ subsequently reported experiences similar to Adson and Brown's following ganglionectomy and trunk resection.

In 1924, pre-operative and post-operative calorimetric studies were made by Brown^{11, 12} of patients on whose sympathetic apparatus Adson operated for spastic conditions. The report showed that elimination of heat following operation had increased on an average of 400 per cent., and that this increase had remained permanent. These data suggested the practicability of applying surgical procedures in vasospastic diseases, and such an operation was carried out with success by Adson,⁴ March 19, 1925, in a case of Raynaud's disease of the lower extremities. Subsequent study of this patient and of others has shown that vasodilatation has remained, and that the patients have been free from all symptoms. Adson first carried out cervicothoracic ganglionectomy and trunk resection by the posterior⁵ approach July 31, 1928. Following success in the treatment of Raynaud's disease patients with other diseases in which vasospastic phenomena were manifested were likewise subjected to the operation. Before these operations could be performed, however, it was apparent that some measure had to be devised to determine, before operation, the degree of vasomotor spasm present, and whether this spasm could be sufficiently relaxed to justify the surgical procedure.

The studies of capillaries made by Brown¹⁰ offered some assistance, but the variations in temperature indicating flow of blood served as a better index. Therefore, Brown¹¹ introduced studies of cutaneous temperatures.

Vascular Studies.—We can record only relative estimates of volume flow of blood; the number of capillary loops to a given field, the rate of flow of the corpuscles, and the elimination of heat and the temperature of the skin that are dependent on the flow of blood can be determined. By the Stewart-Kegerreis calorimeter it was possible to estimate the radiation of heat before and after operation, but it was not until Brown,^{13, 14} suggested recording the temperature of the skin before fever had been induced, and during its course, that there was any accurate knowledge concerning vasospasm. The thermocouples of the electrothermometer are fastened to the various portions of the fingers, toes, hands, feet and body, in preparation for readings of surface temperature. First, readings are recorded of the temperature of the room, and of the mouth and surface of the skin. Thus, corrections can be made for the environmental temperature, and the temperature of the mouth and skin can be compared with the corresponding temperatures of a normal person, and with the readings taken during the height of fever. The fever is produced by administering, intravenously, a foreign protein, for example, 5,000,000 to 75,000,000 triple typhoid vaccine. The dose depends on the weight and sex of the patient. Hourly readings are made until the maximal rise of fever has been obtained. These readings are compared with the initial temperatures, to determine the ratios of increased temperature. General, regional, and spinal anæsthesia produce vasodilator effects and can be employed instead of administration of protein.

In studying the temperature of a normal person, it will be observed that the temperature of the mouth may have increased as much as an average of 2° C., whereas the temperature of the skin over the digits will have increased 4° to 6° C., or two to three times the mouth temperature, indicating that the peripheral arteries have been opened by inhibition of the vasomotor centre and that more blood has been permitted to flow to the periphery. In cases of vasospastic disorder, the difference in temperatures is still greater, since the initial surface temperature of the digits is lower than that of a normal

subject exposed to the same room temperature. In cases of general arterial sclerosis there may be little, if any, difference in the skin temperatures before and after administration of the foreign protein, indicating that the vessels are incapable of relaxing to allow increase of the flow of blood to the periphery. In cases of thrombo-angiitis obliterans it is possible to determine whether there exists an element of vasomotor spasm of the collateral vessels and unoccluded arteries; it is possible, too, to determine, by individual readings, the condition of each digit. Therefore, the test serves as an index, and unless the rise in temperature of the skin of the digits is two or more times greater than the rise of the oral temperature, the condition is considered inoperable. The test also permits determination of the degree of collateral circulation in different portions of the same digit. This aids us in arriving at a prognosis concerning the preservation or loss of digits with ulceration.

Further to substantiate the opinion that vasomotor spasm exists and is due to stimuli of central origin carried over post-ganglionic gray rami to the arteries instead of being due to a local fault³² in the arterial walls, we have observed that increased blood flow with resulting increased temperature is readily produced by anæsthesia of the vasomotor nerve by nerve block, and regional and spinal anæsthesia. In cases of Raynaud's disease the color changes are immediately abolished by anæsthesia, and during the anæsthesia they cannot be reproduced by emotional stimuli or exposure to cold. Similar results are obtained by a thorough interruption of gray rami which is most effectively accomplished by removing the sympathetic ganglia with resection of trunks carrying vasomotor fibres. Following cervicothoracic ganglionectomy the retinal arteries and veins have been found to be dilated from one and a third to one and a half the pre-operative size. Repeated calorimetric and cutaneous temperatures in cases of sympathectomy have revealed that the increased blood flow has been maintained for seven years in the cases in which operation was first performed. The real problem is to select suitable cases for operation and to decide when operation is indicated. It is obvious that vasodilatation cannot be produced in an arteriosclerotic or occluded artery, and that surgical intervention is useless unless there is positive evidence of vasospasm in the remaining nonoccluded arteries. The operation is not indicated in the milder cases, in those that respond quickly and favorably to medical treatment, nor in cases of massive gangrenous lesions, but is indicated for the slowly progressive lesions.

Surgical Technic.—Inasmuch as the surgical technic has been described previously,^{2, 4, 5} we shall not go into details as it is generally accepted that the vasomotor innervation of the arteries and veins does not run centrifugally along the vessels, but that the vessels receive their innervation at various levels corresponding to the musculo-cutaneous segments. Although Leriche²⁴ conceived the idea that vasodilatation might be accomplished by interrupting the vasomotor fibres by a peri-arterial stripping operation, the operation was not of sufficient scope to include all of the nerves. If the vasomotor fibres are divided by ramisection or ganglionectomy and trunk resection,^{2, 6} it is immaterial which method is used so long as they are completely resected. In treating peripheral vascular diseases of the toes and feet we prefer to use the abdominal transperitoneal approach which permits removal of the second, third and fourth lumbar sympathetic ganglia with the intervening trunk through an abdominal incision. In sympathectomy of the vessels of the fingers and hands we choose the posterior approach,

resecting a portion of the first rib and the transverse process of the first thoracic vertebra on each side in order to enter the mediastinum and remove the inferior sympathetic cervical and first thoracic ganglia with the upper portion of the thoracic trunk. Occasionally, we can include the second thoracic ganglion through the same incision. When we are unable to include this ganglion we divide all ascending rami to the first thoracic and eighth cervical nerves. We believe this operation to be more thorough than the anterosuperior approach since it is difficult to include all of the vasomotor fibres in the gray rami coming from the second and first thoracic ganglia by the anterior and superior approach.

Raynaud's Disease.—Mild¹ vasospastic phenomena such as cold, moist hands and feet, or symmetric pallor of one or more digits without pain, numbness or trophic changes can scarcely be interpreted as constituting the symptoms of Raynaud's disease, although in such cases the physiopathological state is identical to that in Raynaud's disease. The diagnosis of Raynaud's disease is reserved for cases in which there is symmetric pallor, followed by cyanosis in which it is difficult to induce recovery, and in which the patients complain of numbness and aching pains during the stages of pallor. This condition is most common among young, asthenic women and among women of middle life who are chronically fatigued and subjected to severe mental strain. The milder forms of the disease rarely require special treatment and these milder forms may be controlled by improving social and economic states, such as avoiding certain social contacts, making new friends, avoiding overfatigue, changing occupation, changing climate, or wearing warmer clothing. The severe types continue to progress in spite of medical measures, and trophic changes appear, such as deformed nails, dry ulcers, scleroderma, and occasionally gangrene of the digits.

When medical treatment is inadequate, surgical procedures are instituted with the purpose of relieving vasomotor spasm. Following the interruption of all vasomotor fibres, the pain disappears, swelling subsides, ulcers heal, nails grow, the characteristic color changes disappear, arterial pulsations increase, and the skin appears normal, pale pink and distinctly warmer and drier. However, cyanosis has been seen to occur in fingers with ulcerated tips when held in dependent positions and exposed to cold following sympathectomy. Ulcers heal and do not recur.

In³ order to evaluate the results of sympathectomy in the treatment of Raynaud's disease in its various degrees of severity, cases have been classified in three groups. In the first group the cases are uncomplicated and the patients complain of asphyxia and cyanosis associated with paræsthesia. In the second group are more advanced cases of active ulceration. In the third group are the most advanced cases in which ulcer or gangrene is associated with marked evidence of scleroderma and arthritis.

A review of Tables I and II will show that the disease affects the upper extremities more often than the lower, and that the results from lumbar sympathectomy are better than those from cervicothoracic sympathectomy. The incomplete results in the fingers are apparently due to failures to include all of the vasomotor fibres when using the second rib approach, or to the

advanced stage of the disease which has produced permanent changes in the peripheral circulation which does not permit vasodilatation of the arterioles or return to normal of the tremendously dilated capillaries.

TABLE I

The Incidence of Raynaud's Disease in the Sexes, Average Age, Duration of Disease Previous to Sympathectomy, the Relation of the Involvement to the Upper and Lower Extremities, and the Number of Operations Performed

Group	Type of Disease	Cases	Age, Years	Male	Female	Average Duration of Symptoms, Months	Average Duration Since Sympathectomy, Months	Cervicothoracic Sympathectomy	Lumbar Sympathectomy
1	Uncomplicated	16	33.6	1	15	58.6	34	11	5
2	With ulcers	6	25.7	0	6	71	40.7	3	3
3	With ulcers or gangrene with scleroderma and arthritis	32	33.0	3	29	79	25.7	25	7
	Totals	54	30.7	4	50	69.5	33.2	39	15

The post-operative sequelæ of these surgical procedures result in dryness of the skin, which can be relieved by application of lanolin and cocoa butter. Horner's syndrome of apparent enophthalmus, contracted pupils, and lagging of the lids due to relaxation of the musculus tarsalis is not a serious disfigurement if it is bilateral, nor does it interfere seriously with vision at night. Resection of the upper portion of the thoracic sympathetic trunk, and of the corresponding ganglia, does not alter materially acceleration of the heart, and none of the patients subjected to the procedure has complained of cardiac symptoms after operation. There have been no deaths to date.

Thrombo-angiitis Obliterans.—Thrombo-angiitis⁷ obliterans is a peripheral vascular disease, characterized by thrombosis of the peripheral arteries and veins, resulting in intermittent claudication, localized pain, œdema, ulceration and gangrene of digits, and in the later stages of the disease,⁶ massive gangrene. Besides the process of thrombosis vasomotor spasm of the principal unoccluded and collateral arteries is found, which aggravates the symptoms produced by the occlusion of arteries and veins, and which, if relieved, ameliorates the symptoms, preserves digits and extremities, and aids materially in rehabilitating the patient.

The specific etiology is still undetermined. Some investigators hold that the disease is due to specific infection or to toxic agents. It is most common among young men who are engaged in active exercise, but it also occurs

SYMPATHETIC GANGLIONECTOMY

TABLE II

Results from Cervicothoracic Sympathectomy or Lumbar Ganglionectomy and Trunk Resection for Raynaud's Disease

Group	Type of Disease	Case	Average Relief of Color Changes; Per Cent.	Average Relief of Pain; Per Cent.	Average Healing of Ulcers; Per Cent.	With Recurrent Signs	With Incomplete Sympathectomy
Cervicothoracic Sympathectomy (39 cases)							
1	Uncomplicated.....	11	85	85	No ulcers	None	None
2	With ulcers.....	3	60	60	100	1	1
3	With ulcers or gangrene with scleroderma and arthritis.....	25	85	75	85	4	4
Lumbar Sympathectomy (15 cases)							
1	Uncomplicated.....	5	100	100	100	None	None
2	With ulcers.....	3	100	100	100	None	None
3	With ulcers or gangrene with scleroderma and arthritis.....	7	90	90	90	None	None

among men occupying sedentary positions, and occasionally it has occurred among young women. It is supposed to be more prevalent in the Hebrew race, but it has been found to develop in all races. Some investigators believe that the use of tobacco, especially if in excess, is a causative factor. The exposure to cold has a deleterious effect on the patients.

Symptoms.—Intermittent claudication is one of the earliest symptoms and undoubtedly is due to anoxæmia brought on by exercise or excessive fatigue. This is followed by or associated with postural color changes, that is, rubor with dependency and pallor with elevation. As the disease progresses, localized pain such as pains in the arches of the feet may be present during the period of rest. Trophic changes are manifested by nonhealing abrasions from trauma, ulcerations of digits, and the development of localized or massive gangrene. The disease usually progresses slowly and may remain temporarily quiescent in any one of the earlier stages. In some cases the disease never progresses to ulceration and gangrene, whereas in others the symptoms respond favorably to medical treatment, but more often it slowly involves the opposite extremity. In reviewing this series of 240 cases of thromboangiitis obliterans, it was found that the disease involved the lower extremities in 60 per cent.; it affected the upper extremities alone in 2 per cent., and both upper and lower extremities in 38 per cent. It further was observed

that the disease would sooner or later become bilateral even though more prominent in one extremity. In reviewing these statistics of cases it was learned that the disease was bilateral in 98 per cent. of the cases.

Marked improvement followed active medical treatment in 56 per cent. of the cases, and the incidence of amputation of leg or hand which was 25 per cent., in cases in which treatment was inadequate or not given, had been reduced to 14 per cent. Although medical treatment has been effective and the incidence of amputation has been lowered, the disease progressed in many of the cases, and we were stimulated to look for more effective methods of treatment. This, then, led to the employment of sympathetic ganglionectomy and trunk resection for a group of patients suffering with this disease. Since we had no criterion to follow in the selection of suitable cases at the beginning of the investigation, we were compelled to progress by trial and error. As experience developed we found we can determine pre-operatively the patients who will respond to sympathectomy, since we can reproduce the increased blood flow with the increased skin temperatures produced by vaccine therapy and have found that these effects remain continuously increased, whereas the effects of vaccine therapy are only temporary.

Selection of Cases.—On admission and during examination these patients are classified according to an outline proposed by Brown, Allen and Mahorner.¹³

Slow Progression.—This is the most common type. Coldness of the feet is usually the first symptom, followed by excessive fatigue of single digits, the arch of the foot, the wrist, ankle, calf, or forearm. Excessive fatigue gradually changes into and is replaced by the pain of claudication occurring in similar areas which progresses and produces an increasing degree of disability. Color changes with change of posture are followed by trophic changes which occur spontaneously or are incited by incision of toes, removal of toenails, accidental trauma, amputation of toes, or the application of blistering ointments. With the occurrence of trophic changes the pain is sharply accentuated and becomes almost unbearable. The gangrenous areas increase in extent requiring amputation, or healing may occur in a group in which pain can be relieved. The extremities are cold, there is excessive pallor with elevation and abnormal rubor with dependency. Pulsation in the arteries is diminished or absent. The entire process is completed in from four to eight years.

Absence of Progression.—In this type mild symptoms of vascular insufficiency (excessive fatigue or the pain of claudication) progress slowly for a time and then remain stationary. The extremities are cold, the arteries are obliterated, and postural color changes are present. Trophic changes other than proliferation of the nails and increased thickening of the skin over the weight-bearing area do not occur. Disability is minimal in spite of symptoms which may have endured from eight to twelve years.

Circulatory Compensation.—This type is not widely recognized although it is fairly common. Shallow ulcers do not progress and after from six months to a year healing occurs. Gradually other symptoms largely dis-

appear, leaving the patient with extremities approximately 80 per cent. adequate for all needs. With care patients in this group may go on indefinitely with extremities functioning sufficiently well for all ordinary needs. Weber³³ has noted the return of pulsation in an obliterated radial artery and this has been observed in several of our cases.

Acute Fulmination.—In this type the clinical syndrome is the antithesis of slow progression. Claudication appears relatively suddenly and progresses rapidly. The rest pain is severe before gangrenous changes occur and greatly accentuated afterward. Œdema and lymphangitis are present around the gangrenous area and there may be slight fever and leucocytosis. The gangrene progresses rapidly, the pain is unbearable and intractable to all measures. Amputation is necessary. The process may be complete after from three months to one year.

On completion of the examination which includes laboratory and vascular studies, we decide on the course of treatment, basing our judgment not only on the condition of the vascular system but on the present status and course of the disease. As previously stated, the operation is not employed in mild cases without ulcers; neither is it employed in cases in which there has been no progression nor in which the circulation has become compensated. It is never wise to urge operation during the acute stage of inflammation with active cellulitis. This type of patient should be hospitalized and treated medically from three to six weeks.

The slowly progressive cases which include most cases of thromboangiitis obliterans are most suitable for sympathectomy, and even then when extensive ulcers or gangrenous digits are present, we are inclined to hospitalize patients for two or three weeks under vaccine therapy in order to determine how the individual patient is going to respond to the vasodilating effect obtained by administration of protein before sympathectomy is performed. If the disease affects both the lower and upper extremities we usually carry out sympathetic ganglionectomy and trunk resection to interrupt the vasomotor fibres to the extremities affected first and then wait six weeks until the patient has thoroughly recovered before performing the second operation. We usually perform bilateral sympathectomy even though the disease appears to produce symptoms in only one extremity, since ultimately it is almost sure to involve the opposite extremity, and since sympathectomy has apparently controlled the process and preserved the opposite extremity. However, recurring phlebitis may develop in either extremity following sympathectomy, but this, aside from producing localized pain and œdema, does not jeopardize the life of the extremity.

Results.—A review of the statistics of 100 consecutive cases of thromboangiitis obliterans in which sympathetic ganglionectomy and trunk resection had been done disclosed that bilateral lumbar operation was done eighty-nine times and cervicothoracic ganglionectomy fifteen times. Four patients were operated on for thromboangiitis obliterans for both the upper and lower extremities, which accounts for the 104 operations. The series included

ninety-six men and four women; their average age on admission was thirty-five years. The average duration of symptoms on admission was four years. The legs had been amputated in sixteen cases, an arm had been amputated in one case and in several cases toes had been amputated previous to admission. Sixty-three patients complained of intermittent claudication, sixty-one of whom had obtained 85 per cent. relief of symptoms. Eighty-three patients complained of rest pain, of whom sixty-nine obtained 85 per cent. relief. Twenty-five complained of continued pain or the development of recurrent pain following sympathectomy. Twelve patients had œdema of the extremity involved, seventy-seven came for observation complaining of ulcers, thirty-four had gangrenous digits, and three had massive gangrene of the extremity. In ten cases following sympathectomy recurring phlebitis developed, in nine ascending arterial occlusion developed which was probably due to the fact that the patient was operated on during an acute stage of ascending thrombosis. Recurring ulcers or gangrene developed following operation and dismissal in seven cases; in this group five legs and one foot were amputated. Eighty-seven patients were markedly improved following sympathectomy, receiving an average relief of 80 per cent., and seventy-six patients obtained a useful extremity. In the absence of trophic lesions sympathectomy checked the progress of the disease in the opposite extremity in every case. Seven patients still complained of symptoms of neuritis, two of whom were subjected to chordotomy with only moderate success; one patient had a leg amputated and others had cutaneous nerves divided without success. Five patients had post-operative pneumonia, and two of them died. One patient died from a pulmonary embolism. Two patients died from cardiac failure immediately following operation, and the sixth patient never recovered from the results of the anæsthetic (ethyl [1 methylbutyl] barbituric acid).

The only deaths that occurred from sympathectomy in the treatment of Raynaud's disease, thrombo-angiitis obliterans and scleroderma occurred in cases of thrombo-angiitis obliterans. It would appear that the lesion is not only confined to the peripheral arteries of the extremity but probably also affects terminal arteries in other organs, as it was demonstrated in the two deaths from cardiac disease.

Scleroderma.—Adson, O'Leary and Brown,⁸ in 1929, stated that a third of the patients who consult a dermatologist for scleroderma give a history of vasospastic phenomena simulating Raynaud's disease. Scleroderma also may accompany thrombo-angiitis obliterans and certain types of arthritis. The vascular spasm in scleroderma is more or less continuous, and produces a constant reduction of the supply of blood to the extremities.¹⁴ Since the spasm and cyanosis can be temporarily relieved by application of heat, by the use of general, spinal, and regional anæsthesia, and by the administration of vaccine, this condition was studied in a manner similar to that in which Raynaud's disease was studied. The changes in scleroderma simulate these that arise from a plaster cast that is too tight; namely, cyanosis, swelling,

pain, atrophy, contracture, deformities, and disuse. This type of scleroderma differs from the amorphous type in that the disease affects chiefly the skin over the hands, forearms, face, neck and scalp. The atrophy and contracting processes of the skin are associated with similar processes in the underlying structures, and it is not unusual for a patient to complain of weakness, inability to use muscles, and inability to open the mouth or protrude the tongue. Arthritic changes often become manifest in the fingers; this condition is referred to as sclerodactylia. The changes associated with scleroderma are more pronounced in the skin of the uncovered parts, such as the hands, forearms, face and neck, than they are in the covered parts, which suggests that reflex stimuli of cold accentuate existing vasomotor spasm. The fact that underlying tissues are subjected to atrophic changes suggests that vasospasm is not confined to the vessels of the skin, but that it does interfere with the circulation of all tissues.

Care should be exercised in selecting suitable cases, since the hide-binding process of scleroderma strangulates and destroys capillaries and arterioles which naturally cannot be opened by a vasodilating procedure. The vasomotor index again serves its purpose in the selection of operable cases. The post-operative results are dependent on the stage of the disease. The vascular phenomenon is corrected, as in Raynaud's disease, and rehabilitation of skin and adjacent tissues will take place if vasomotor spasm is present, and not too many capillaries and arterioles have been destroyed. If it is not possible to demonstrate the desired increase in surface temperature by administration of protein, little is to be expected from operation. Ankylosed joints are not made flexible by sympathetic ganglionectomy and trunk resection. It is wiser to choose the earlier cases for operation; improvement is more likely to occur in these cases than in advanced cases in which deformity has taken place.

Results.—The cases were divided into three groups and classified on the basis of the relationship of the vasospastic phenomena to the development of the disease. In the first group were cases of primary scleroderma with vasomotor phenomena developing late in the disease; in the second group were cases in which scleroderma and vasomotor disturbance developed simultaneously. In the third group vasomotor disturbances preceded the development of scleroderma.

In the first group the vasomotor phenomena were improved, the skin temperature was increased, the skin became more flexible and ulcers healed, but the result could not be compared with that in the third group; the outstanding accomplishment was the checking of the disease with an average improvement of 10 per cent.

In the second group the results were similar to those in the first group, added to considerable restoration of function, with an average improvement of 25 per cent.

In the third group recoveries following lumbar sympathectomy averaged 85 per cent. whereas following cervicothoracic sympathectomy they averaged 45 per cent. In this group the skin not only became pink, warm, soft and

flexible but the muscles again became fusiform and flexible which resulted in improvement of strength. Patients who had been unable to open their mouths or protrude their tongues were again able to masticate their food as formerly. The skin still remained very thick and bruised easily; ankylosed joints were unchanged.

BIBLIOGRAPHY

- ¹ Adson, A. W.: The Indication for, and Therapeutic Value of, Sympathetic Ganglionectomy and Trunk Resection in the Treatment of Peripheral Vascular Diseases. *Colorado Med.*, vol. xxvii, pp. 460-467, December, 1930.
- ² Adson, A. W.: Cervicothoracic Ganglionectomy, Trunk Resection, and Ramisectomy by the Posterior Intrathoracic Approach. *Am. Jour. Surg.*, vol. xi, pp. 227-232, February, 1931.
- ³ Adson, A. W.: The Results of Sympathectomy in the Treatment of Peripheral Vascular Disease, Hirschsprung's Disease and Cord Bladder. *Ann. Int. Med.* (In press.)
- ⁴ Adson, A. W., and Brown, G. E.: Treatment of Raynaud's Disease by Lumbar Ramisectomy and Ganglionectomy and Perivascular Sympathetic Neurectomy of the Common Iliacs. *Jour. Am. Med. Assn.*, vol. lxxxiv, pp. 1908-1910, June 20, 1925.
- ⁵ Adson, A. W., and Brown, G. E.: Raynaud's Disease of the Upper Extremities; Successful Treatment by Resection of the Sympathetic Cervicothoracic and Second Thoracic Ganglia and the Intervening Trunk. *Jour. Am. Med. Assn.*, vol. xcii, pp. 444-449, February 9, 1929.
- ⁶ Adson, A. W., and Brown, G. E.: The Treatment of Raynaud's Disease by Resection of the Upper Thoracic and Lumbar Sympathetic Ganglia and Trunks. *Surg., Gynec., and Obst.*, vol. xlviii, pp. 577-603, May, 1929.
- ⁷ Adson, A. W., and Brown, G. E.: Thrombo-angiitis Obliterans; Results of Sympathectomy. *Jour. Am. Med. Assn.* (In press.)
- ⁸ Adson, A. W., O'Leary, P. A., and Brown, G. E.: Surgical Treatment of Vasospastic Types of Scleroderma by Resection of Sympathetic Ganglia and Trunks. *Ann. Int. Med.*, vol. iv, pp. 555-568, December, 1930.
- ⁹ Archibald, Edward: Effect of Sympathectomy upon the Pain of Organic Disease of Arteries of the Lower Limbs and for Obscure Abdominal Pain. *Tr. Am. Surg. Assn.*, vol. xlvi, pp. 179-189, 1928.
- ¹⁰ Brown, G. E.: The Skin Capillaries in Raynaud's Disease. *Arch. Int. Med.*, vol. xxxv, pp. 56-73, January, 1925.
- ¹¹ Brown, G. E., and Adson, A. W.: Calorimetric Studies of the Extremities Following Lumbar Sympathetic Ramisectomy and Ganglionectomy. *Am. Jour. Med. Sci.*, vol. clxx, pp. 232-240, August, 1925.
- ¹² Brown, G. E., and Adson, A. W.: Physiological Effects of Thoracic and of Lumbar Sympathetic Ganglionectomy or Section of Trunk. *Arch. Neurol. and Psychiat.*, vol. xxii, pp. 322-357, August, 1929.
- ¹³ Brown, G. E., Allen, E. V., and Mahorner, H. R.: *Thrombo-angiitis Obliterans*. W. B. Saunders Co., 219 pp., Philadelphia, 1928.
- ¹⁴ Brown, G. E., O'Leary, P. A., and Adson, A. W.: Diagnostic and Physiological Studies in Certain Forms of Scleroderma. *Ann. Int. Med.*, vol. iv, pp. 531-554, December, 1930.
- ¹⁵ Bruning, Fritz: Weitere Erfahrungen über den sympathicus. *Klin. Wchnschr.*, vol. ii, pp. 1872-1874, 1923.
- ¹⁶ Davis, Loyal, and Kanavel, A. B.: The Effect of Sympathectomy on Spastic Paralysis of the Extremities. *Jour. Am. Med. Assn.*, vol. lxxxvi, pp. 1890-1893, June 19, 1926.

- ¹⁷ Diez, J.: El tratamiento de las afecciones tróficas y gangrenosas de los miembros por la resección de las cadenas cérvico-torácica y lumbo-sacra del simpático. *La prensa med.*, vol. xii, pp. 377-403, 1925-1926.
- ¹⁸ Fulton, J. F.: Vasomotor and Reflex Sequelæ of Unilateral Cervical and Lumbar Ramisectomy in a Case of Raynaud's Disease, with Observations on Tonus. *ANNALS OF SURGERY*, vol. lxxxviii, pp. 827-841, November, 1928.
- ¹⁹ von Gaza, W.: Die Resektion der paravertebralen Nerven und die isolierte Durchschneidung des Ramus communicans. *Arch. f. klin. Chir.*, vol. cxxxiii, pp. 479-500, 1924.
- ²⁰ Jaboulay: Quoted by Leriche.²⁴
- ²¹ Jonnesco, Thomas: Traitement chirurgical de l'angine de poitrine par la resection du sympathique cervico-thoracique. *Presse méd.*, vol. xxix, p. 193, 1921.
- ²² Kramer, J. G., and Todd, T. W.: The Distribution of Nerves to the Arteries of the Arm, with a Discussion of the Clinical Value of Results. *Anat. Rec.*, vol. viii, pp. 243-255, May, 1914.
- ²³ Kuntz, Albert: The Autonomic Nervous System. Philadelphia, 576 pp., Lea and Febiger, 1929.
- ²⁴ Leriche, René: De l'elongation et de la section des nerfs périvasculaires dans certains syndromes douloureux d'origine artérielle et dans quelques troubles trophiques. *Lyon chir.*, vol. x, pp. 378-382, 1913.
- ²⁵ Leriche, René, and Fontaine, René: Chirurgie du sympathique. *Rev. neurol.*, vol. i, pp. 1046-1085, 1929.
- ²⁶ Mayo, W. J.: Observations on the Sympathetic Nervous System. *Brit. Med. Jour.*, vol. ii, pp. 627-628, October 18, 1930.
- ²⁷ Orbeli, Z. A.: Personal communication to the authors.
- ²⁸ Potts, L. W.: The Distribution of Nerves to the Arteries of the Leg. *Anat. Anz.*, vol. xlvii, pp. 138-143, July, 1914.
- ²⁹ Ranson, S. W.: Anatomy of the Sympathetic Nervous System with Reference to Sympathectomy and Ramisection. *Jour. Am. Med. Assn.*, vol. lxxxvi, pp. 1886-1890, June 19, 1926.
- ³⁰ Royle, N. D.: The Treatment of Spastic Paralysis by Sympathetic Ramisection, *Surg., Gynec., and Obst.*, vol. xxxix, pp. 701-720, December 1924.
- ³¹ Scrimger, F. A. C.: On the Possibility of Relieving Abdominal Pain by Section of the Sympathetic Rami Communicantes. *Canadian Med. Assn. Jour.*, vol. xxi, pp. 184-189, August, 1929.
- ³² Simpson, S. L., Brown, G. E., and Adson, A. W.: Raynaud's Disease; Evidence that It Is a Type of Vasomotor Neurosis. *Arch. Neurol. and Psychiat.*, vol. xxvi, pp. 687-718, October, 1931.
- ³³ Weber, F. P.: Return of Pulsation in Thrombo-angiitis Obliterans. *Brit. Med. Jour.*, vol. ii, p. 52, July 12, 1924.

DISCUSSION.—DR. ARTHUR W. ALLEN (Boston) remarked that the general management of peripheral vascular lesions cannot be overemphasized. Unless one is willing to go to the trouble of caring for these individuals in a standardized, routine way, then operations and various other forms of specific therapy are likely to fail. It also has another bearing on the subject. If one places these people under observation, under ideal circumstances, with certain routine procedures, looking after their general hygiene, fluids, food, exercise, and so forth, one will find in a very large percentage of the arteriosclerotic, particularly those associated with diabetes, and in a certain number of cases of thrombo-angiitis obliterans, that they will lose their so-called rest pain in a period of a week or ten days and from then on one's treatment may be varied accordingly, and general measures may be all that are needed.

They had had a good many failures in their cervicodorsal sympathectomies. The cases presented here had all been operated upon more than one year ago.

They have had under observation in a three-year period over 400 cases of peripheral vascular lesions. Thirty-seven of these have been what are called primary vasomotor disease or Raynaud's disease. Fifty-one they have classified as secondary vasomotor imbalance with scleroderma in some cases; certain types of arthritis, and so forth. Eleven of these primary cases of vasomotor imbalance or Raynaud's disease have been subjected to sympathectomy. All of these patients have been incapacitated at the time of the operation. Fifteen cervicodorsal operations and eight lumbar operations have been done on these eleven patients. In the cervicodorsal operations there have been eleven returns of vasomotor control. In the secondary group the results have been somewhat better. There have been ten of these patients. Nine have had cervicodorsal sympathectomy and five lumbar sympathectomy. There have been three cases that have reestablished vasomotor control in the cervicodorsal region.

A summary of the twenty-one patients in both the primary and secondary groups: there were twenty-four cervicodorsal operations; with a return of vasomotor influence in fourteen sides, in eight patients.

These results are somewhat discouraging. None of the lumbar ganglionectomies has shown any signs of return of vasomotor control. All of these had vasomotor influence eliminated, as shown by sweating tests immediately after the operation. All had a very high vasomotor gradient.

In eighty-eight patients with thrombo-angiitis obliterans under observation, not very many have been found in whom it was felt that operations upon the sympathetic nervous system would be of benefit. Perhaps they have overlooked opportunities along this line, but most of these individuals who do not have rest pain or open lesions will respond to general routine measures and certain palliative ambulatory procedures which have been described elsewhere.

The group that is incapacitated with rest pain, with open lesions and painful ulcerations has not in their hands been relieved of their pain by ganglionectomy. They have, therefore, resorted in twenty-nine cases in this group to peripheral nerve block as described by Smithwick and White. In this very advanced, hopeless group of thrombo-angiitis obliterans, the results have been very much better with the nerve block than with any other procedure which they had found, although in the twenty-nine cases so treated there had been eleven major amputations.

DR. MARTIN B. TINKER (Ithaca, N. Y.) emphasized the great relief some chronic arthritis patients experience. A patient under his care, who had used sedatives every night for over six months, was immediately relieved and even post-operatively did not require sedatives.

Another point which had impressed him was the ease of the approach by the incision suggested by Doctor Robertson. He had been convinced that the retroperitoneal approach was simpler and safer than the transperitoneal. In two operations within a week after seeing Doctor Robertson's work he had found these patients so surprisingly free from post-operative discomfort, the approach so easy, and it was so easy to expose the sympathetic chain, that he believed personally it is the method of choice.

DR. HOWARD LILIENTHAL (New York City) expressed a hope that the gentlemen who contributed to this discussion would tell him why the people who have thrombo-angiitis obliterans are in so enormous proportion, practically all males. He knew that those we see for the most part come from Central European countries and from Southern Russia.

He also knows that the women in this region are not addicted to smoking, as are the men.

Many years ago, when Dr. B. Sachs and Dr. Alfred Wiener first called attention to the fact that this disease, thrombo-angiitis obliterans (which had another name at that time), was a disease of vascular and not merely arterial origin, the question of tobacco as a cause was first considered.

SYMPATHETIC GANGLIONECTOMY

DR. HARRY H. KERR (Washington, D. C.) was convinced that the question of success following sympathectomy or ganglionectomy was a question of surgery. He said the more thoroughly the ganglia are eradicated, with all their branches, the better the results will be. His largest experience had been in operations for angina pectoris. As his experience develops he is doing more thorough eradications, and getting better results. This is made possible by injection of the ganglia with normal salt solution through a very fine needle. The injection brings out all the branches so that eradication is much more perfect. There was another type of case apparently susceptible to sympathectomy which he would like to put on record. It is sympathectomy for retinitis pigmentosa. Retinitis pigmentosa is a familiar disease characterized by gradual, on-coming blindness, progressive narrowing of the visual fields, and the deposition of pigment in the periphery of the retina. Thoracicocervical sympathectic resection had been reported.

He operated on a case of retinitis pigmentosa by superior cervical sympathectomy. This operation seemed a more direct attack on the sympathectic supply of the eye. The result was dramatic. The patient had visual fields of under 10 degrees; after operation they were increased to between 30 and 40 degrees. His visual acuity, which before operation had been 20/100, went up to 20/40. He operated on another case with apparently not so good results. Possibly incomplete surgery was responsible.

DR. WILLIAM JASON MIXTER (Boston) noted a marked lack of uniformity in the testing of patients with vascular disease and one finds a considerable difference of opinion in the interpretation of results. As time passes and the methods of testing become more uniform the interpretation of these tests will be more uniform also.

The results of operations on the cervicodorsal ganglion have not been altogether satisfactory as there have been a good many recurrences. This is due he believed in part to the difficulty of complete exposure of this ganglion. Complete removal of this ganglion together with the ganglia lower down in the chain is essential. Doctor Harvey and Doctor Oughterson indicate in their work that partial extirpation is not sufficient.

For cervicodorsal ganglionectomy he had been using a transverse incision running from shoulder to shoulder in the form of an arch. This incision is more satisfactory than the longitudinal incision.

There has been no tendency to the recurrence of vasomotor spasm following lumbar ganglionectomy which places this procedure on a much more satisfactory basis.

In Boston there have been done comparatively few lumbar ganglionectomies for thrombo-angiitis obliterans. They have seen good results from peripheral neurectomy or alcohol block. The results of these minor peripheral operations have been very good and they certainly have a place in the treatment of thrombo-angiitis obliterans.

DR. RUDOLPH MATAS remarked that Dr. Mont Reid had referred to oscillometry as an index to the efficiency of the peripheral circulation. The speaker had found an invaluable method of determining the differential blood-pressure in the extremities; and the reason, perhaps, why it has not become more popular and generally utilized in this country, even by those who recognize its value, is that many believe it necessary to use the highly sensitive, but more expensive Pachon instrument. In his experience any ordinary aneroid used for determining the blood-pressure would do perfectly for this purpose provided it did not leak and that the air in the cuff would be kept under perfect control by a well-adjusted screw valve.

After inflating the cuff, the needle would indicate in millimetres the beginning of the oscillations (systolic pressure) and the end of the oscillation (diastolic pressure) and a record could be made in this way more easily and simply than with an imported Pachon. By the utilization of the ordinary sphygmomanometer of the aneroid type the practice of oscillometry would become more generalized.

DR. EDWIN BEER (New York City) said that they had had large experience in this particular disease, pre-senile gangrene, thrombo-angiitis) in the city of New York. In the years past, major amputations used to be a very common procedure for this condition. Since Dr. Samuel Silbert has introduced the hypertonic saline intravenous method of treatment with nerve block and the use of glonoin in large doses, major amputations are a rarity. He therefore believed that ganglionectomy and peripheral sympathectomy should be used only when more conservative measures have been carefully tried and have failed.

DR. JOHN J. MORTON (Rochester, N. Y.) desired to add to Dr. Collier's contribution on tobacco that they had also noted this vasoconstriction effect but when vasoconstriction is once established in these people, even if one gets them to give up smoking, they will not recover from their attacks, according to their experience.

DR. ASHLEY W. OUGHTERSON (New Haven, Conn.) emphasized that it may take some time to get the temperature of the extremity down to its lowest level. In the case reported in his paper while the color changes in the hand were striking, they were not so pronounced as in the feet, and it required exposure to a temperature of 65° for several hours before the lowest temperature could be obtained. There seems to be critical temperatures at which one can demonstrate vasoconstriction when there are only a few remaining fibres. Obviously, it is a quantitative effect, and if there are only a few fibres left, vasoconstriction cannot be demonstrated as easily as when all the fibres are present.

DR. MONT R. REID (Cincinnati) said that it seemed to him that we do not take this problem with quite as much seriousness as we should. We are, perhaps, trying to find some method of treatment which will not interfere too much with the normal return of a patient's life. Peripheral vascular disease is a very serious proposition and sacrifices may be just as necessary in the treatment of this condition as, for instance, in the treatment of tuberculosis. In a great many cases of arteriosclerotic disease a very radical change or readjustment of work and mode of life would make it possible for many persons to carry on without ever developing any serious complication. A great many of the spastic and inflammatory conditions, by proper care continued over a long period of time, would become arrested and develop an adequate or more or less adequate collateral circulation.

The sacrifice might have to be as great as it is in cases of tuberculosis, but the analogy is not far-fetched. He said if he had thrombo-angiitis obliterans, he would feel that he had to pay the price of a year or a year and a half of the most extraordinary care to try to stop the process, cause a healing and the establishment of an adequate collateral circulation.

DR. A. W. ADSON said that their evaluation of treatment was based on a study of 640 cases; 400 of these were examined and treated previous to 1924 and 240 have been under observation since 1924 and have been subjected to very careful study. In reviewing this group it was learned that the incidence of amputation of extremities was 25 per cent. in the non-treated or poorly treated group which was lowered to 15 per cent. in the well-treated medical group and 6 per cent. in the sympathectomized group.

During the development of sympathectomy in the treatment of thrombo-angiitis obliterans they were usually offered patients for treatment who could not afford hospitalization or would not respond to medical management but as their experience had grown they had come to select patients who had responded to vascular studies and who had presented distinct evidence of a slowly progressive disease.

He believed that sympathectomy had come to remain as a useful means in the treatment of peripheral vascular disease. He said additional investigation is required before all can agree on the surgical indications.

THE TREATMENT OF TRIGEMINAL NEURALGIA BY THE CEREBELLAR ROUTE

BY WALTER E. DANDY, M.D.

OF BALTIMORE, MD.

THIS report is concerned with the treatment of trigeminal neuralgia by the subcerebellar route. Soon after its inception a report of the procedure was read by title at the Richmond meeting of the American Neurological Association in 1925. At that time its advantages had not yet appeared, and the old Hartley-Krause procedure as modified by Spiller and Frazier and others was such a satisfactory and safe procedure it was not then considered to be a substitute for this widely used method of attack. Gradually, however, as the cases multiplied, it was discovered empirically that most of the liabilities which followed the temporal route did not obtain when the nerve was sectioned by the cerebellar route.

In the Archives of Surgery, in 1929, a report of the first eighty-eight cases was presented. At that time the advantages of this method had become apparent. At the present time 250 cases of trigeminal neuralgia have been operated upon by the cerebellar route and it is now used exclusively in our clinic. Since this publication the procedure has been modified in many ways which contribute to both its ease and safety. In the last 150 cases there has been no death either at operation or during their stay in the hospital, and there have been no post-operative complications.

The steps in the operative approach are as follows: A small curved incision is made just back of the mastoid on the side of the neuralgia. (Fig. 1.) A small defect is made in the bone, the mastoid process is rongeuired away to, but not into, the mastoid cells. (Fig. 1.) The dura is opened, the cisterna magna is evacuated; the cerebellar lobe is then gently elevated and the fluid evacuated, after which the fifth nerve is in full view and is divided either subtotally or totally as desired. The dura is then closed and the galea and superficial wound reunited. The operation is done either under avertin or local anæsthesia. As a matter of fact, it lends itself very easily to local anæsthesia, with which it can be performed almost painlessly except for the brief moment during which the nerve is sectioned and the pain at that time is really very slight. An advantage of local anæsthesia is that the pain fibres in the sensory root may be identified by their sensitivity when touching them; after these fibres have been divided the remainder of the nerve is insensitive.

Since the report in 1929 the following technical improvements have been made:

First.—Avertin anæsthesia has been substituted for ether, either by inhalation or per rectum. This is a great advantage because there is no swelling

of the cerebellum as obtains with ether and there is therefore ample room for exposure of the cerebello-pontine angle in all cases. Furthermore, it provides perfectly smooth breathing which rarely follows ether, and which is so essential when the sensory root is divided.

Second.—The electrocautery makes it possible to easily coagulate and divide the petrosal vein should this be necessary. (Fig. 2.) This vein is merely pinched with forceps through which the current is passed to obliterate the vessel. The control of the petrosal vein and its branches was really the only element of danger in the operation and this can now be easily and

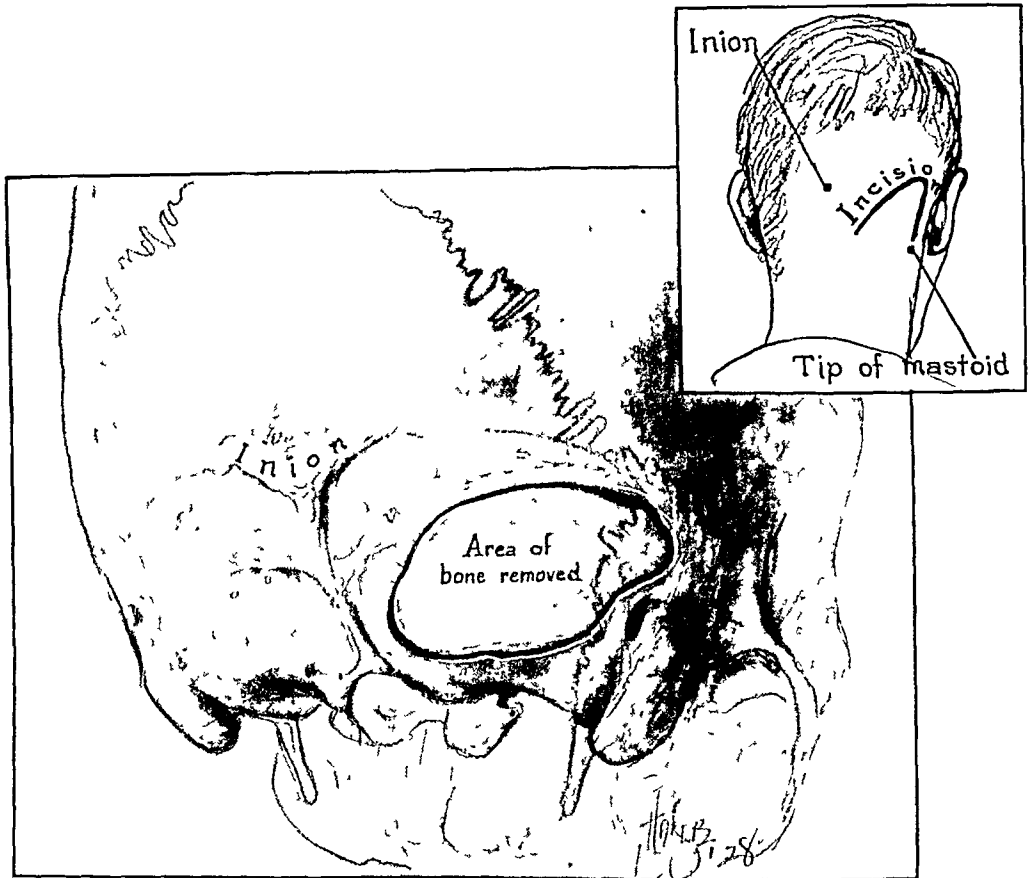


FIG 1—Showing cutaneous incision and area of bone removed in order to expose the trigeminal nerve by the cerebellar route

safely overcome, if necessary, with the cautery. As a matter of fact it is only once in about fifteen cases that it is necessary to occlude the petrosal vein for in the remaining cases the sensory root is not at all obscured by this vessel.

Third.—Suction is now used to evacuate the fluid in the cisterna lateralis; this makes it unnecessary to sponge and, therefore, it not only saves time but avoids any possible injury to the auditory nerve, which lies at a safe distance posteriorly. Suction is applied indirectly through a pledget of cotton that is placed in the cisterna lateralis. (Fig. 3.) It acts, therefore, as through a wick.

TRIGEMINAL NEURALGIA CEREBELLAR ROUTE

Fourth.—Formerly a sharp knife on a long handle was used to divide the sensory root. The division of the sensory root is now performed much more easily and safely by using either a blunt hook or by pinching the nerve with the blades of a long narrow forceps. (Figs. 2 and 3.) It requires very little force to interrupt the nerve fibres.

Fifth.—The dura is always closed over the entire defect. In one of the early cases an intracerebellar hæmorrhage resulted because of trauma to the cerebellum when post-operative vomiting thrust the cerebellum against the sides of the bony defect.

The sensory root may be either partially or totally divided by this pro-

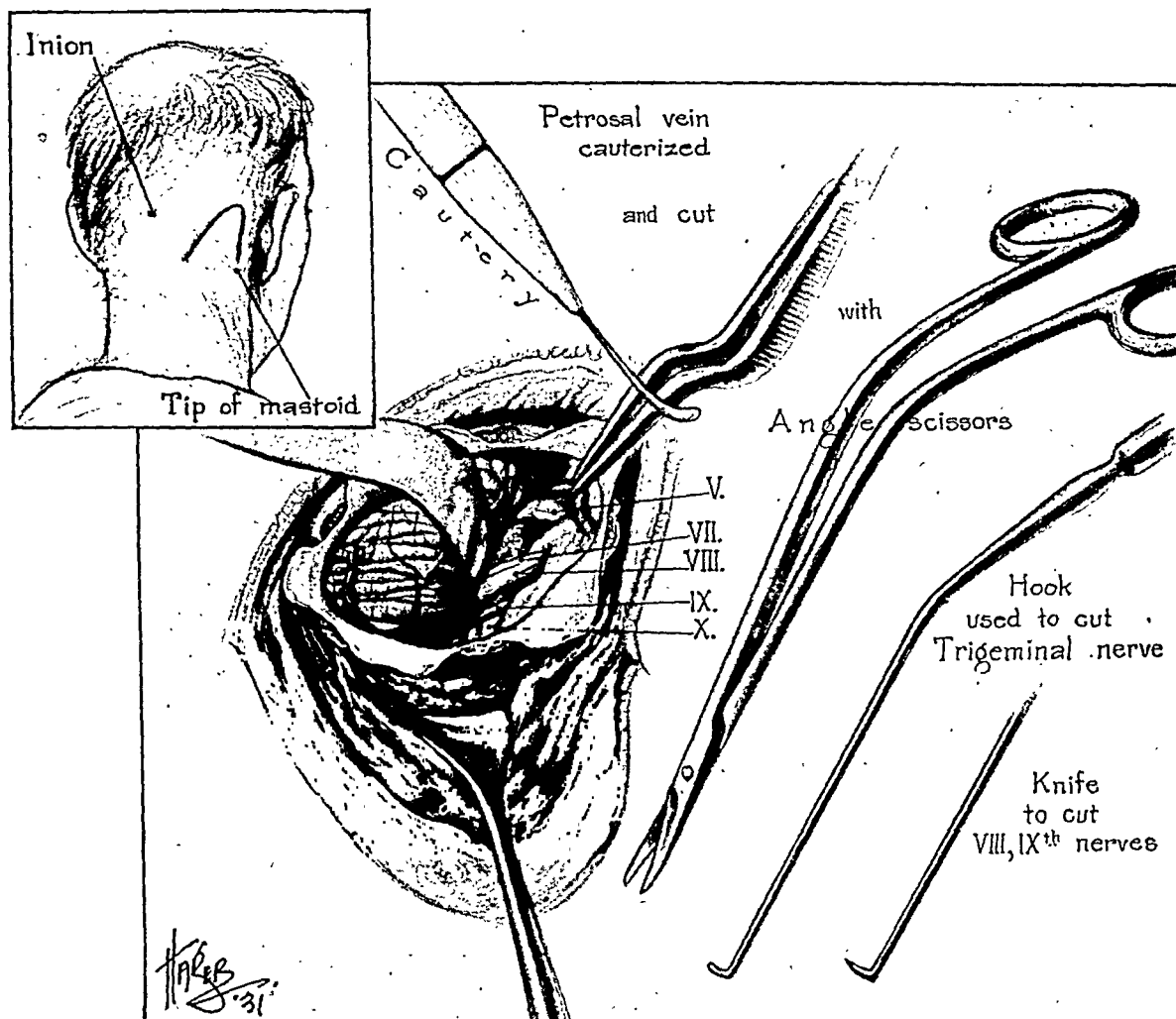


FIG. 2.—Instruments used in dividing the various nerves in the posterior cranial fossa. If necessary the petrosal vein may be obliterated by the cautery. This is only occasionally necessary. The sensory root is usually divided with a blunt hook, or it may be pinched with the forceps.

cedure with equal facility. In my experience the operation is far easier to perform than by the temporal route. The average time required is perhaps one-half hour from the incision to the division of the sensory root, though in many cases it has been performed in ten to fifteen minutes. This is mentioned not as any great point of merit, but because the operative procedure has been frequently criticized as being very difficult and dangerous. In four cases in this series the patients have been over eighty years of age.

The advantages of the subcerebellar route are as follows:

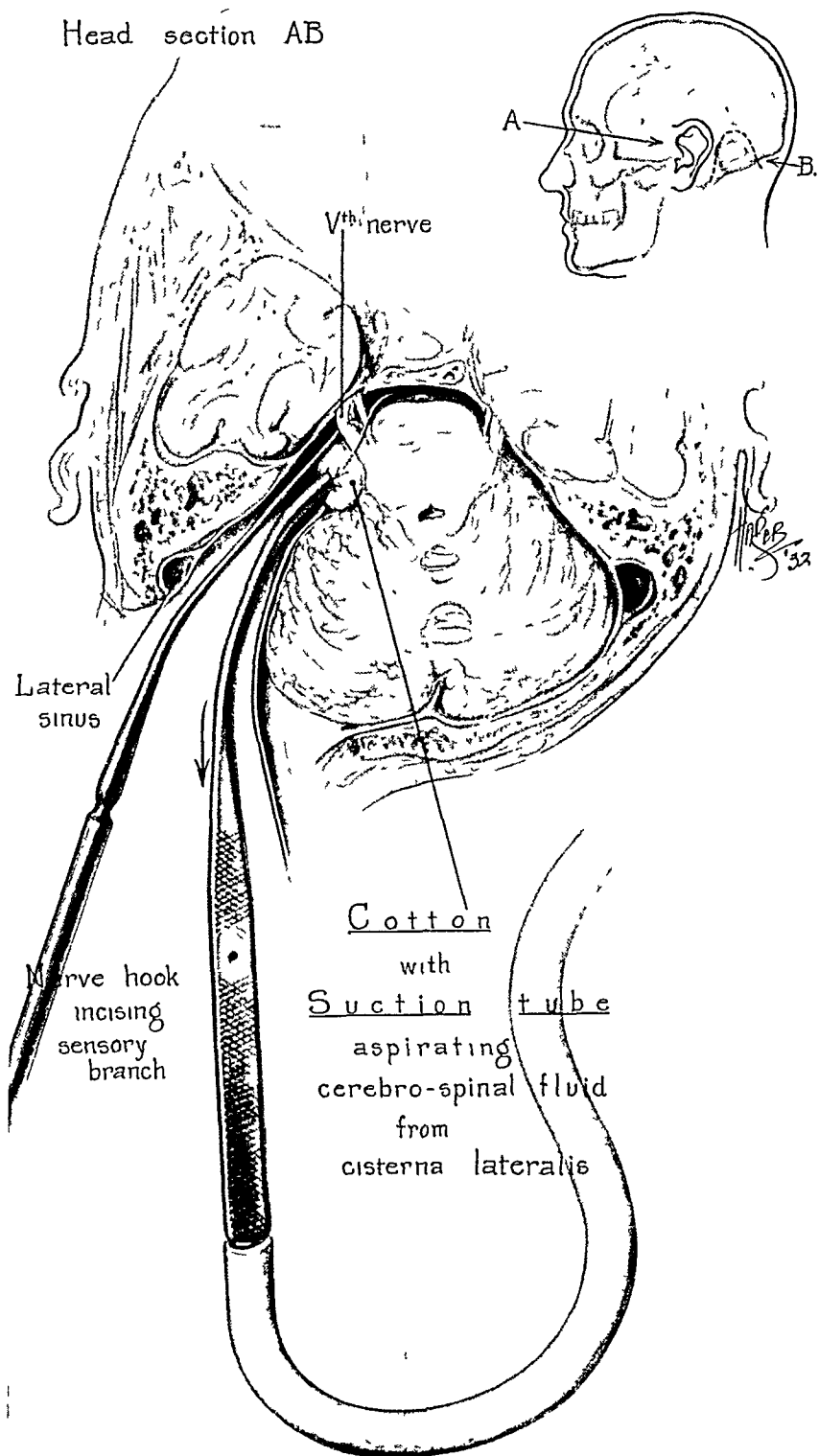


FIG 3—Withdrawal of fluid from the cisterna lateralis by suction applied through a pledget of cotton The diagram shows method of partial division of the sensory root

TRIGEMINAL NEURALGIA CEREBELLAR ROUTE

(1) In no instance has there been the well-known post-operative keratitis. It has been shown that the incidence of keratitis following soon after section of the sensory root is dependent upon the amount of trauma inflicted upon the nerve. The reason for the absence of keratitis, which is one of the principal complications of the temporal route, is that only a few seconds are required to divide the nerve after it has been exposed. This statement does not mean, of course, that keratitis may not follow at any subsequent time if the eye is injured following a total section of the nerve.

(2) The motor root of the nerve has never been injured since this route has been employed because it is at a greater distance from the sensory root than at any other point in its course. This is of special advantage in operations for double trigeminal neuralgia, of which we have had eight cases. Furthermore, if the patient has double tic douloureux, the pain can be cured on both sides by a single operation using the bilateral cerebellar approach, such as is used in nearly all exposures of cerebellar tumors. Each cerebellar lobe is then elevated in turn and the sensory root divided on each side. By the temporal route two operations are necessary, and, should the motor root be injured on one side a tremendous responsibility would rest upon preservation of the motor branch on the other side.

(3) The facial nerve is never injured because it is at a safe distance. It will be remembered that the facial nerve is injured by the temporal route when the petrosal nerve is torn from the geniculate ganglion in elevating the dura from the floor of the middle fossa.

(4) Another important advantage of the cerebellar route is that in eighteen of our 250 cases tumors have been disclosed in the posterior cranial fossa. (Figs. 4, 5 and 6), and most of these have been removed at the same time the sensory root is divided. In all of these cases the tumor was the cause of the neuralgia and, of course, would have been missed entirely if the temporal route had been used. It is impossible to differentiate by clinical tests those cases in which the tic douloureux is caused by a tumor.

It is worthy of note in passing that in perhaps one-third of the cases of trigeminal neuralgia a gross lesion is disclosed which we think is responsible for the trigeminal neuralgia. Aside from tumors the two common causes are, free arterial loops which lift the sensory root from the brain stem, and the venous branches which cross the nerve, sometimes dividing it into two parts.

The incidence of recurrence in the subtotal section of the sensory root by any method should be mentioned. There have been four recurrences in our series. I have previously shown that division of the posterior half of the sensory root will cure the pain in any branch of the nerve and with practically no loss of sensation. From this observation I have interpreted the findings to mean that the fibres which are responsible for this unique pain are collected from all branches of the trigeminal nerve into the posterior part of the sensory root. However, variations in this distribution must occur and these doubtless account for the occasional recurrences. In one instance there was a recurrence in the second branch when only about one-tenth of the

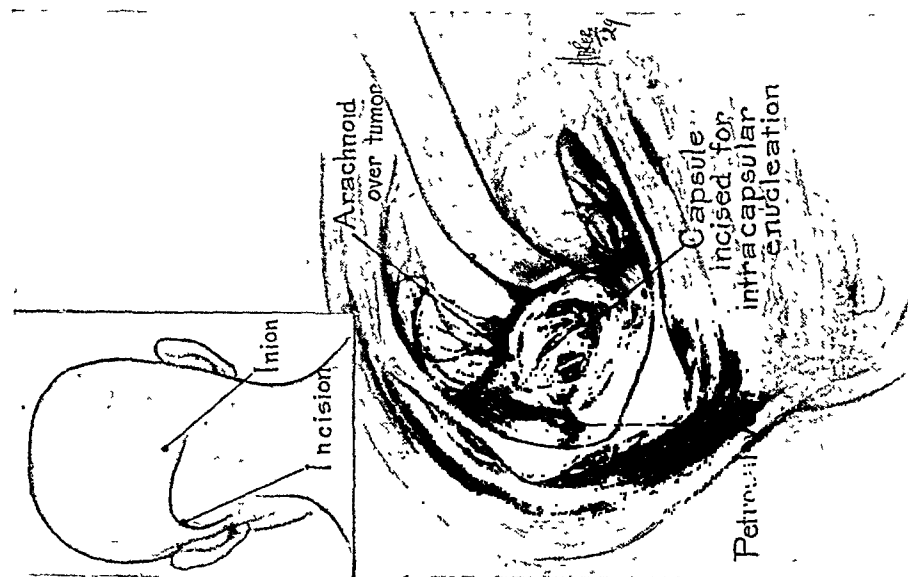


FIG. 4.—Small dural endothelioma in the cerebello-pontine angle causing trigeminal neuralgia.

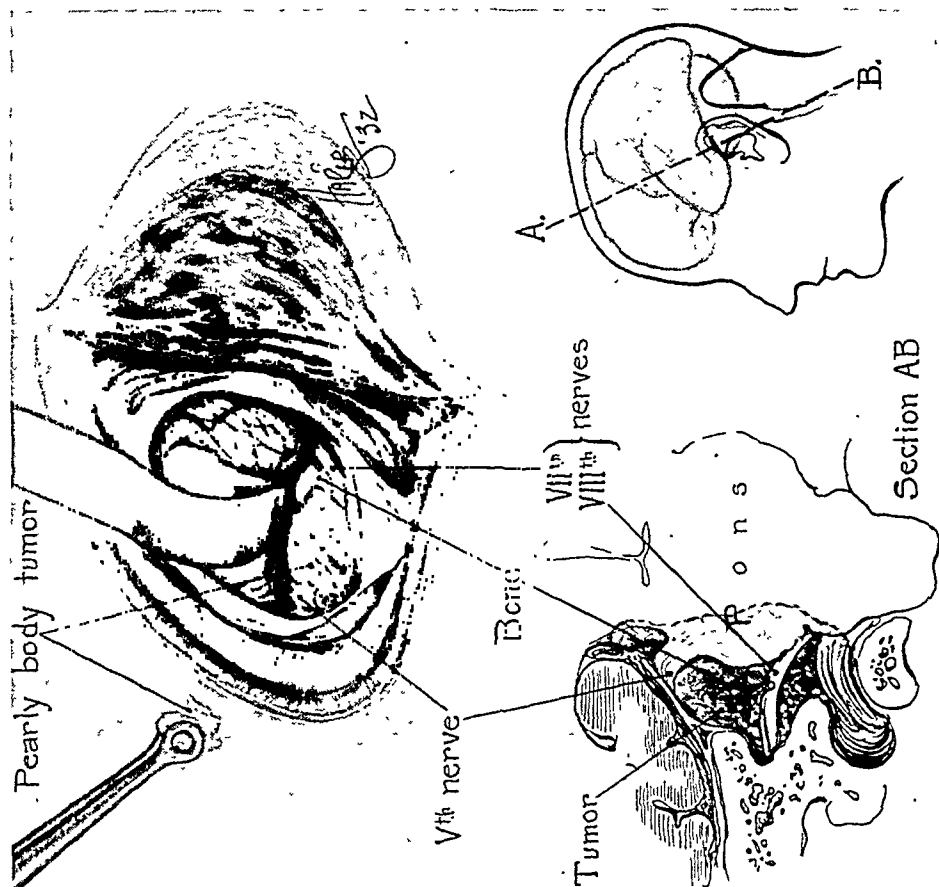


FIG. 5.—Pearly tumor in the cerebello-pontine angle causing trigeminal neuralgia.

TRIGEMINAL NEURALGIA CEREBELLAR ROUTE

anterior part of the sensory root remained. Should a recurrence develop it is a very simple matter to again open the incision, elevate the cerebellum and complete the section of the nerve. The existence of the cisterna lateralis prevents the formation of adhesions and, therefore, there are no difficulties in a second stage at any later time. Because of the possibility of recurrence it is my plan in patients of advanced age to totally divide the nerve rather than to run the slightest risk of another attack. In younger people I feel it is much more important to preserve the sensation of the face intact or nearly so, and run the slight risk which a partial division entails.

Mention should perhaps also be made in this connection of the use of this approach for patients who have carcinoma of the tongue and pharynx. Relief of pain for such patients is not possible by alcoholic injections or by peripheral division of nerves. Such pain is referable to the sensory domain of both the fifth and the ninth nerves, and by the cerebellar approach (under

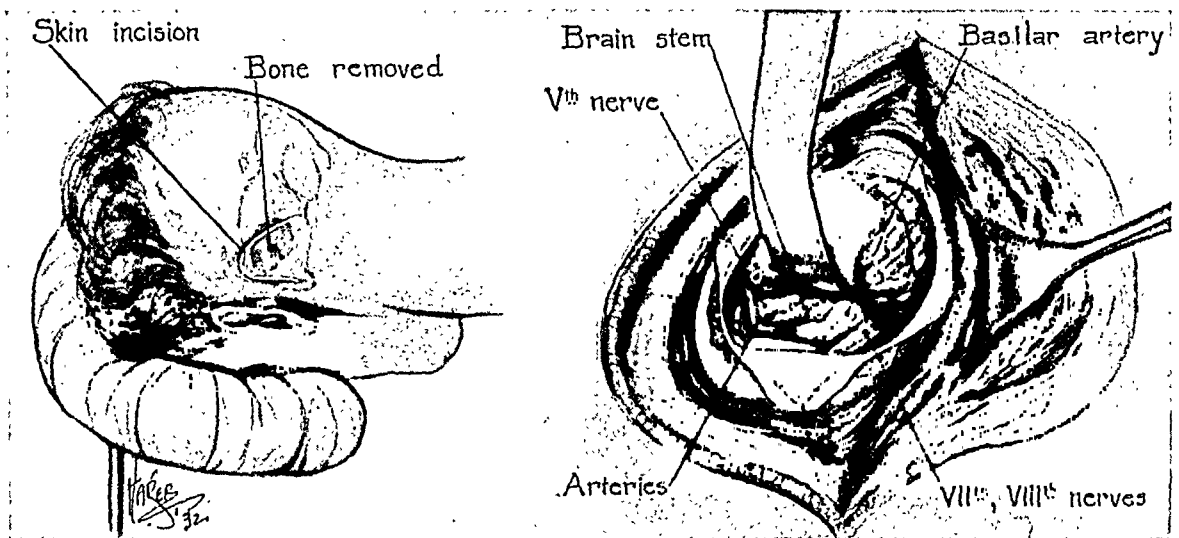


FIG. 6.—Aneurism of basilar artery causing trigeminal neuralgia.

novocaine) both the fifth and the ninth nerves may be divided intracranially and with practically the same ease as obtains for the division of the fifth nerve alone.

The same operative approach is also used in dividing the eighth nerve for Ménière's disease, and the ninth nerve for glossopharyngeal neuralgia.

To Recapitulate.—The operation as now improved, is, in safe hands, one of the safest in cranial surgery. It almost entirely avoids the complications which still follow section of the nerve by the temporal route.

DISCUSSION.—DR. CHARLES H. FRAZIER (Philadelphia) remarked that although the sensory root from the ganglion to the pons in man is but two centimetres long, yet there has been considerable controversy in the past years as to its structure, more specifically as to the arrangement of its fasciculi, first with regard to disassociated forms of sensation such as pain, temperature, and touch, and secondly as to the arrangement of the fasciculi and their relation with the three different portions of the ganglion and the three peripheral divisions.

In Doctor Dandy's paper certain statements have been made with regard to the root at its entrance to the pons. The speaker's experience with the root has been at its entrance to the ganglion, only two centimetres distant. In a recent communication

Van Nouhuys, of Holland (the statement appearing in one of our recent surgical journals), from a study of the anatomical structure of thirty-eight gasserian ganglions which he had dissected anatomically, stated: *First*, that the sensory root of the fifth nerve is not composed of three parts that correspond to the three peripheral branches; and, *secondly*, that the operation of partial section of the sensory root, assuming that the pain is carried by bundles having a definite location, is not based on anatomical facts, and therefore cannot be regarded as an absolutely reliable procedure.

Doctor Frazier was not qualified to pass judgment upon the technic employed in the examination by Van Nouhuys, the so-called *Zerfaserungsmethode*, or a teasing process, but he had been advised by Doctor Spiller, who has had a fundamental training in pathological technic, that the method is most deceptive and may lead to very misleading conclusions. Doctor Spiller called my attention to the fact that in 1901 he showed that the location of the degeneration of the spinal root by the Marchi method depends on the part of the sensory root cut. He also showed in 1910 that the tactile fibres leave the sensory root at its entrance into the pons and do not form a part of the spinal root.

But wholly apart from the criticism of the technic Van Nouhuys used in his anatomical studies, he wanted at this time to take exception to his conclusion based upon the result of the speaker's experience with subtotal section of the sensory root. Having performed the operation upon the root over 720 times, he felt entitled to an expression of opinion.

He was convinced and submitted in evidence a series of anæsthesia charts selected at random which show that if one sections the outer third of the root, one will have anæsthesia in the mandibular division; that if one sections the middle third of the root, there will be anæsthesia in the maxillary division; likewise, if one sections the inner portion of the root, there will be anæsthesia in the ophthalmic division; in any combination of these operations there will be a corresponding area of anæsthesia.

Subtotal section of the sensory root, therefore, despite Van Nouhuys' statement to the contrary, has proven an absolutely reliable procedure in that it permanently relieves the patient of pain; and, furthermore, if one leaves the ophthalmic portion of the root intact, there is no possibility of trophic keratitis as a complication. He did not see why the motor root is any more readily damaged by the temporal route than by Doctor Dandy's suboccipital route, so there is no greater danger in injuring the root.

As to the percentages of bilateral cases, Doctor Dandy's was very much higher than his. Of almost 2,000 cases of major trigeminal neuralgia which have passed through the clinic, he had knowledge all together of only some twenty cases.

With regard to facial paralysis after the operation, this has been avoided altogether by observing a simple point in the operative technic, to leave on that portion of the skull just behind the ganglion the posterior surface of the ganglion. If one makes sure to leave on this aspect of the base of the skull, just above the surface of the petrous bone, a single layer of the dura, one may always avoid injuring the trochlear nerve.

The temporal route in the hands of the majority of surgeons will be the safer of the two routes, and if it guarantees permanent relief with a hazard of 0.2 per cent., this route should be given preference.

In a recent article (*ANNALS OF SURGERY*, vol. xciv, pp. 1013-1017, December, 1931) Van Wagenen, an impartial observer and an experienced neurosurgeon, in conclusions as to his experience with five cases of section of the sensory root by the suboccipital route, said: "The impression is gained from these and other cases that while the operation is considerably more hazardous and difficult than through the temporal route, it is a valuable adjunct to one's neurosurgical armamentarium. No evidence has been gained from this series of cases that the type or area of anæsthesia differs from that which occurs when the trigeminal root is sectioned via the temporal fossa, provided the root is divided."

TRIGEMINAL NEURALGIA CEREBELLAR ROUTE

DR. WALTER E. DANDY (Baltimore): The point at which the sensory root is divided may account for the difference between the results in Doctor Frazier's operation and mine. I think unquestionably the fibers are responsible for the pain, and these particular fibers must descend into the spinal root.

It was largely the inferior results with the temporal route that led me to search for a different attack. I think it very unfair to make assertions that this approach is highly dangerous when I have done 150 such operations without a death or undesirable operative sequelæ. On the contrary, it is, in safe hands, a very safe procedure, and certainly no more dangerous than the temporal route. I think, unquestionably, the results that are obtainable by this method are much superior to those resulting from the temporal route.

If one is willing to disregard all of the advantages of the cerebellar route, the incidence of removable tumors in the posterior fossa and causing trigeminal neuralgia would alone be sufficient reason for the cerebellar instead of the temporal approach. All of these tumors would, of course, be missed if the sensory root were sectioned by the temporal route. Nor can one differentiate by clinical observations a tic due to a tumor from those in which there is no tumor.

THE INFREQUENCY OF CARCINOMA OF THE CERVIX WITH COMPLETE PROCIDENTIA

By DONALD GUTHRIE, M.D.

AND

WILLIAM BACHE, M.D.

OF SAYRE, PA.

THE interest of the senior writer in this subject was aroused by a discussion with the late John G. Clark, in 1927, just before his death, who asked him how often he had seen carcinoma of the cervix with complete procidentia. Doctor Clark, at that time, stated that in all of his experience he had never seen the two conditions associated.

We believe that the association of carcinoma of the cervix and complete procidentia is so rare that the report of a case is worthwhile, that a review of the literature on the subject and a speculation as to why the two conditions are so rarely seen associated may be of interest.

We have written to many leading gynecologists and general surgeons wishing first to establish the rarity of the condition and to determine, if possible, why in complete procidentia carcinoma of the cervix seldom occurs, when apparently at first thought the existing conditions should be most favorable to its development.

CASE No. B-20077.—J. M., married, aged fifty-three years, admitted December 26, 1929. Marital history: three pregnancies, each terminating in normal delivery, no miscarriages. Six months before admission the patient noticed a mass protruding from the vagina. A short time prior to the discovery of the protrusion she developed a bloody discharge between the menstrual periods. This bleeding began with a normal menstrual period and continued until admission. Because of the protrusion and the bleeding she had worn a tight napkin. Nine months ago she began to lose weight, in spite of a good appetite, and complained of a low backache. She developed attacks of dysuria, frequency and nocturia. She had never had the urine examined before coming to the clinic. She was a well-nourished female with an anxious expression. Heart slightly enlarged, no murmurs, no irregularities. Lungs, negative. Abdomen, negative.

Pelvic Examination.—Complete prolapse of uterus. Cervix is greatly elongated, hypertrophied, the left cervical lip is eroded, ulcerated, bleeds easily to the touch and is indurated. A foul discharge is present.

Blood-pressure.—Systolic, 165; diastolic, 110. Pulse, 84. Temperature, 99°.

Laboratory.—Blood count: hæmoglobin, 75 per cent.; red blood-cells, 4,720,000; white blood-cells, 7,000; differential, 56-44. Kahn, negative. Urine: specific gravity, 1030; alkaline, trace of albumen, 1.2 per cent. sugar, few pus cells, no red blood-cells, no casts. Blood sugar, 307 milligrams per 100 cubic centimetres of blood. Blood urea, thirty-two milligrams.

Diagnosis.—Complete procidentia, carcinoma of cervix, diabetes.

The patient was placed upon a proper diet with insulin and in twelve days she was sugar-free and in condition for operation.

January 7, 1930, operation.—Vaginal hysterectomy, Mayo type for complete prolapse.

Pathologist's Report.—Specimen consists of uterus and cervix thirteen centimetres in length. The cervix everted, ulcerated, greatly hypertrophied, measuring 5.5 centimetres in diameter. Mucous membrane is firm, dark red and slightly eroded. On section the wall of the uterus is 3.5 centimetres thick and contains considerable fibrosis. The cavity of the uterus is large and contains five polyps. The ulcerated area on the left side of the post-cervical lip extends into the cervical canal. Sections taken from this area show carcinoma epidermoid Grade III.

After a stormy and prolonged convalescence, during which time decubitus ulcers developed, the patient was discharged April 15, 1930. She returned to the hospital December 5, 1930, showing undoubted evidence of a widespread metastasis and died January 27, 1931. No autopsy was permitted.

Clinical treatises on gynaecology and surgery pay little attention to the subject. In 1882, Fritsch stated that patients with prolapse of the uterus seemed to be refractory to carcinoma of the cervix. Pomtow, in 1893, reported a case and a review of the literature at that time, finding twenty-eight cases reported in the literature. Andrews, in 1923, reported a case of a patient, aged seventy-seven years, with carcinoma and prolapse. Constantini, in 1923, reported a case, as did Nicholson in the same year. Stajano discussed the clinical differences of traumatism in the development of carcinoma of the cervix seen in prolapse.

A careful examination of the French literature shows practically no cases on record. Delvaux, in 1931, discussed the resistance of the cervix to carcinoma in total prolapse and sent out a questionnaire. In the replies from the various French surgeons he found that Hamant, of Nancy, had never seen a case. Leriche had seen but one case. Brouha had seen no cases. Foure had seen four cases, but considered it rare. Hartmann never had seen carcinomatous degeneration of the cervix with prolapse. Sebrechts had operated upon many hundreds of cases of complete prolapse and had never seen carcinoma with prolapse. Pauchet replied that true carcinoma of the cervix with procidentia is practically never seen. Backer, too, believed carcinoma of the cervix to be very rare and in the examination of 11,000 women failed to see a single case of carcinoma of the cervix with prolapse.

In 1932, Matyas reports a case of sarcoma of the cervix in a young patient of twenty-three with prolapse.

C. C. Norris (personal communication, 1930) reports that six cases were recorded in a discussion before the American Gynaecological Society a few years ago; and one or two instances were placed on record before the Philadelphia Obstetrical Society. The combined experiences of the members of these societies are enormous.

Judd, of The Mayo Clinic, reports but three cases of carcinoma of the cervix in about 2,188 cases of procidentia.

Smith, Graves and Pemberton report having seen three cases of carcinoma of the cervix in 1,000 procidentias.

In the questionnaire referred to above, reasons for the infrequent association of carcinoma of the cervix and prolapse were invited and the number of cases seen by each surgeon, or in different clinics, was requested. A brief analysis of forty-eight replies will now be given.

Twenty-eight surgeons (58.3 per cent.) reported having never seen a case, among whom were Novak, Anspach, Baldy, Vaux, Ward, Piper, Royster, Bartlett, Brent, Casler, Gellhorn, Montgomery, Müller, Maes, Keen, Hirst, Mitchell and Gardner. No cases have been seen in the Crile and Lahey clinics. It is very safe to say that the combined experience of these outstanding gynaecologists and general surgeons represents a study of many thousands of cases of procidentia. Two surgeons report finding carcinoma of the body associated with complete procidentia, but neither has seen carcinoma of the cervix with complete procidentia.

Eleven men report having seen one case, among whom are Abell, Sampson, Cullen, Richardson, Healy, Chalfant, King, Norris, Payne and Haggard.

Four men—Jeff Miller, McGlinn, the late J. O. Polak, and Taussig—report having seen two cases. Farmer has encountered the condition three times; Howard Kelly and A. H. Curtis both report having seen a very few cases.

Thirty-two surgeons (62.5 per cent.) offer no explanation for the infrequent association of carcinoma of the cervix with complete procidentia. Sixteen suggest various reasons for the rarity; less vaginal secretion and free drainage was mentioned nine times; cornification of the cervical epithelium resists the development of carcinoma was suggested nine times; the lessened area of infection in a prolapsed cervix may safeguard the patient from developing carcinoma was spoken of four times. Sixteen men mention chronic irritation and chronic ulceration of the cervix in prolapse, but do not believe it the cause of carcinomatous development. Three men suggest the usual factors which cause carcinoma, but do not mention what these factors are. One believes prolapse develops at a later time in life than that in which carcinoma of the cervix is seen; one, that the patients seek operation for carcinoma of the cervix before prolapse has taken place; another, that carcinoma of the cervix forms a fixed point and prevents prolapse occurring; one, that the carcinoma may form before the prolapse; two surgeons suggest that the absence of acid secretion may be the cause and another mentions an unknown constitutional factor.

In analyzing these various reasons why carcinoma of the cervix is seen so infrequently with procidentia, the cornified cervical epithelium becoming resistant to the development of carcinoma and less vaginal secretion, absence of infection and free drainage appear to be the commonest reasons given for the protection against carcinoma.

Smith, Graves and Pemberton, in reporting their three cases in 1,000 patients with procidentia, believe that good pelvic drainage with the absence of retained chemically changed irritating secretions plus a cornification of the epithelium of the cervix are the reasons for the infrequent associations. When the cervix is exposed to chronic irritation and dried by exposure to the air it becomes more like skin, cornified and hardened, which is not as vulnerable a tissue as some of the softer structures, as mucous membrane; only when insults are continued for a long time on an irreducible prolapse is the epithelial differentiation unable to maintain the balance of the continuous new cell formation and there results an epithelial over-growth which Waldeyer considers carcinoma to be.

In regard to free drainage, it is well to remember also, that carcinoma is more easily produced in animals by chemical irritation rather than traumatic irritation. With free drainage there is a lack of chemical irritation.

Procidentia with carcinoma of the cervix may be influenced by the age group, for carcinoma of the cervix is usually seen in relatively younger women, the older women thus have gone safely through the period when carcinoma usually develops, finally developing prolapse without carcinoma; those of the younger age may develop carcinoma of the cervix and are cured or succumb before procidentia develops; also, carcinoma of the cervix by causing fixation of the uterus may prevent the development of procidentia. It is well known that carcinoma is wont to develop at points of fixation in other organs and systems.

The ulcers seen on the irritated cervixes with prolapse are more often of the decubitus type. When the prolapse is complete, there is torsion of the blood-vessels which greatly reduces circulation with resultant venous stasis. The process is very much like that seen in varicose ulcers of the leg; there is œdema, venous congestion and sclerosis of the skin, which lead to atonic ulceration, with little tendency to cicatrization. The ulcers which often ap-

pear are trophic in type. When the situation of carcinoma is considered, it is always in an area of good blood supply as well as in an area of chronic irritation. (C. H. Mayo, de Takats and Novak.)

Has the acid secretion in the vagina something to do with the development of carcinoma of the cervix? Carrell, in keeping alive malignant tissue, found that this tissue developed an acid area on its advancing margins whereas the margin about growing normal tissue, was alkaline. W. J. Mayo brings up this point and says: "Carcinoma of the stomach is common, but here again there is an acid secretion. In carcinoma of the stomach is the reduction in acidity a result of the cancer, or has it more direct relationship? Again, in the colon where cancer is frequent, the secretion, like that in the vagina, is acid as a result of bacterial action. Have the acid secretions something to do with the development of carcinoma in the presence of chronic irritation?"

One must not forget the specific diathesis of the individual patient when considering reasons for the development of carcinoma in any given case; there should be a hereditary factor together with the proper kind and amount of irritation at the proper time. In many of the cases conditions favorable for the presence of carcinoma of the cervix were present in the form of laceration from childbirth and infections, the carcinoma developing after the prolapse. Would carcinoma have developed in some of these patients had procidentia not occurred?

The number of cases reported is too great for the rarity to be used as an argument against the irritation theory entirely; on the other hand, no matter how great the irritation to which the prolapsed cervix is exposed by rubbing of the clothing, the thighs, tight supporting pads, irritation from urine, carcinoma of the cervix probably does not occur without a hereditary predisposition on the part of the patient.

Delvaux pleads for a systematic investigation of this mysterious immunity of the cervix to carcinoma in the presence of procidentia and believes, strongly, that as a result of such an investigation, there would be a great advance in the discovery of the etiology of cancer.

BIBLIOGRAPHY

- Andrews, H. L.: Carcinoma of a Prolapsed Cervix in a Woman Aged Seventy-seven. *Proc. Roy. Soc. Med., London, Sect. Obs. and Gynec.*, vol. v, p. 16, 1922-1923.
- Constantini, and Montero: Cancer of the Cervix During the Course of a Complete Genital Prolapse. *Bull. Soc. d'obst. et de gynec.*, vol. xii, p. 298, 1923.
- Delvaux, F.: Resistance of the Cervix to Cancer in Total Prolapse of the Uterus. *Bruxelles med.*, vol. xi, p. 325, 1931.
- Matyas, M.: Sarcoma of the Cervix with Prolapse. *Zentralbl. f. Gynak.*, vol. lv, p. 2739, 1931; *Abstract Amer. Jour. Cancer Mch.*, 1932.
- Nicholson, E.: Cancer of Cervix and Total Prolapse. *Bull. Soc. d'obst. et de gynec.*, vol. xvii, p. 117, 1928.
- Pomtow, G.: Carcinoma of the Prolapsed Uterus. *Inaugural Dissertation*, p. 30, Berlin, 1893.
- Smith, Graves, and Pemberton: Procidentia. *Amer. Jour. Obst. and Gynec.*, vol. xvii, p. 669, 1929.

DISCUSSION.—DR. F. N. G. STARR (Toronto) recalled an elderly woman of seventy-five whom he saw years ago. After she had had a procidentia for some thirty years she began to have bleeding. At first she thought she was renewing her youth but when the bleeding persisted and the foul discharge occurred, she sought some relief. Doctor Starr found she had a carcinoma and did a vaginal hysterectomy. He promised her he would drink a cup of tea with her on her eighty-fifth birthday, and that came off just about a year ago.

DR. JAMES C. MASSON (Rochester, Minn.) said he had operated on several cases with extensive prolapse, with extensive ulceration, and in many of these cases the patients thought they had malignancy, and their attending physician had thought malignancy existed, but in his own experience he had never operated on a patient with complete prolapse of the uterus in which cancer of the cervix existed. He considered the age factor as the most important consideration. The majority of women who develop malignancy of the cervix develop it close to the menopause time. At that age, he said, we see very few patients with complete procidentia. Later on, after the menopause, on account of the atrophy associated at that time, if there is a tendency to prolapse, the uterus rapidly sinks to a lower level. That is the time these women consult a surgeon for procidentia. The acid secretion of the vagina probably is a factor predisposing to cancer of the cervix and when the cervix protrudes beyond the vulva, this cause is eliminated.

EDITORIAL ADDRESS

The office of the Editor of the *Annals of Surgery* is located at 131 St. James Place, Brooklyn, New York. All contributions for publication, Books for Review, and Exchanges should be sent to this address.

Remittances for Subscriptions and Advertising and all business communications should be addressed to the

ANNALS OF SURGERY
227-231 South Sixth Street
Philadelphia, Penna.

ANNALS *of* SURGERY

Vol. XCVI

NOVEMBER, 1932

No. 5

TRANSACTIONS AMERICAN SURGICAL ASSOCIATION

MEETING HELD MAY 16, 17 AND 18, 1932; *Continued*

SPLENECTOMY IN PURPURA HEMORRHAGICA

BY ELDRIDGE L. ELIASON, M.D., AND L. K. FERGUSON, M.D.

OF PHILADELPHIA, PA.

PURPURA hemorrhagica or thrombocytopenic purpura is still a medical and surgical problem, although its existence was first noted more than 150 years ago. Despite much work and attention directed towards a solution of its etiology and pathology, the answer is not yet. An attempt is here made to marshall all the information that is available in the literature and to present a critical analysis of this data which analysis gives the numerous theories and a brief description of the work done, in demonstrating the possible etiological factors of this strange disease. The true symptomatology is discussed and a real differential diagnosis urged as an aid in successful treatment. All the available reported cases and five personal cases are presented, while a comparative analysis is made in an attempt to show the value of splenectomy in both the acute and chronic forms and also to demonstrate that the mortality has been appreciably reduced in the last four years, chiefly by reason of proper pre-operative and post-operative transfusions flanking a well-executed splenectomy.

Purpura hemorrhagica was first described by Werlhof,¹⁸ in 1775. Knowledge concerning the nature of the disease developed gradually, until even today there is no complete agreement as to the etiological factors concerned nor as to the mechanism by which these factors act. Denys,²⁵ in 1887, first observed that the blood-platelets were missing in a case of purpura. Nine years later (1896), Hayem⁵⁸ showed that in purpura there was a failure of clot retractility. Duke,²⁹ in 1910, demonstrated that a thrombocytopenia and fibrinogen lack have very definite effects on bleeding time. He pointed out that the reduction of platelets in purpura hemorrhagica is associated with an increased bleeding time, but not with any marked variation in the coagulation time. Hess⁶⁰ showed conclusively that there was a marked weakening of the capillary vessels in purpura hemorrhagica as evidenced by the petechial and even large subcutaneous hæmorrhages which developed distal to a tourniquet applied to the upper arm tight enough to obstruct the venous flow.

These findings stimulated an investigation of blood-platelets, especially

concerning their function in maintaining a normal bleeding time, and as to the reason for their decrease in purpura hemorrhagica. It is now fairly well accepted by all workers in hematology that blood-platelets take their origin from the megakaryocytes of the bone-marrow. These cells are also found in the spleen in disease and in embryonic life,^{84, 87} one of the evidences of close relationships between the units of the hemopoietic system.

The normal function of blood-platelets has been investigated both experimentally and clinically. Janeway, Richardson and Park,⁸⁷ in animal experiments, showed that an extract of platelets has a vasoconstrictor action, not found in an extract of any of the other formed elements of the blood nor in platelet free plasma. Hirose⁸¹ showed that there was a direct proportion between the platelet count and the vasoconstrictor effect of defibrinated blood when brought into direct contact with the surviving carotid of an ox. Brill and Rosenthal¹² presented evidence to show that capillary hæmorrhage is normally stopped by the production of small platelet thrombi, and by the contraction of the vessels. The function of the platelets in the production of a retractile clot has been explained by Glanzmann.⁴⁷ Finally, there is evidence^{12, 80} to show that the platelets produce a thromboplastic substance which has a function in the production of a clot.

The cause of the reduction of platelets in purpura hemorrhagica has been the subject of much controversial reasoning and of considerable experimentation. Frank¹¹ believed that there was a decreased platelet formation, an aplasia or decreased production of megakaryocytes in the bone-marrow caused by a myelotoxin coming from the spleen. He therefore called the disease essential thrombopenia.

Brill and Rosenthal state there is no diminution in the megakaryocytes in the bone-marrow in purpura hemorrhagica but they believe that the fragmentation of the pseudopods does not take place properly because in this disease the platelets are large and irregular and granular in appearance. (This change in the appearance of the platelets in purpura hemorrhagica was noted also by Rockwood and Sheard¹²¹ in a photomicrographical study.) Brill, *et al.*, believed that the spleen is responsible not only for the alteration in the nature and properties of platelets in purpura hemorrhagica but also that it is the site of the destruction of the defective bodies. Krumbhaar⁸¹ considers it probable that the spleen exerts "some regulatory influence on the megakaryocytes of the bone-marrow, the site of platelet formation." Mills¹⁰¹ is not sure that the spleen is primarily responsible for the alteration of platelets, but suggests that destruction of altered platelets is one of the normal functions of the spleen.

Kaznelson^{72, 73, 74, 76} outlined his opposition to Frank's decreased platelet *production* theory somewhat as follows: (1) If there were an inhibition of megakaryocyte production there should also be an alteration in other blood-cells formed by bone-marrow. (2) If there were a bone-marrow lesion, how could splenectomy effect an almost immediate cure? (3) The large size of the platelets found in purpura hemorrhagica indicates a stimulation of bone-marrow. He believes that the enlargement of the spleen often found in purpura suggests that that organ may be the site of the platelet destruction. For this reason he named the disease thrombocytolytic purpura and he suggested splenectomy as a means of treatment.

Experimentally, many investigations have shown that the injection of antiplatelet serum and anti-spleen serum decreases the platelets in the circulating blood.^{9, 88} Various toxic and irritating substances when injected into the blood-stream also lower the platelet count.³⁰ Most authors now agree that the decrease in platelet content of the blood cannot alone account for the symptoms of hæmorrhage produced in purpura hemorrhagica. The belief is general that there is also a lesion of the capillaries,^{9, 12, 18, 100, 110} and that in purpura the entire reticulo-endothelial system is at fault.

Because the spleen is thought to be the organ in which the destruction of the defective platelets takes place, Kaznelson,⁷² in 1916, first suggested splenectomy as a means of

SPLENECTOMY IN PURPURA HEMORRHAGICA

treating these patients. He noted an almost immediate cessation of bleeding and a rapid and marked increase in the number of blood-platelets after extirpation of the spleen. This observation has been confirmed many times since Kaznelson's first case, both experimentally,^{8, 84, 129} and by numerous surgeons who have performed splenectomies for purpura hemorrhagica. Bedson⁶ has shown in guinea-pigs that for three or four weeks after splenectomy while the platelet count is still high, antiplatelet serum has no effect in dosages sufficient to cause fatal purpura in normal control animals. Both experimental and clinical observers have noted a gradual fall after the immediate rise in the number of platelets after splenectomy and during the fall Bedson found his animals normally susceptible to antiplatelet serum.

The question has been raised as to whether the removal of the spleen *per se* is the effective agent in causing the increase in platelets after splenectomy. Holloway and Blackford,⁶⁴ in studying the platelet counts of the splenic artery and the splenic or peripheral veins, failed to bear out the platelet-destroying function of the spleen. Much of the experimental work seems to show that although splenectomy does produce a rapid rise in blood-platelets, other operations of equal magnitude produce similar results. Bachman and Hultgren,³ Liles,⁹³ and Steiner and Gunn,¹²⁰ have demonstrated these facts in rabbits and they conclude that "the degree of rise in the platelet count depends upon the amount of trauma sustained by the tissues."

Dawbarn, Erlam and Evans²² found a rise in the platelet count after operation, fractures and child-birth, beginning on the sixth day and reaching a maximum on the tenth. The platelets reached the normal number again in about three weeks. They believe that the common factor is injury to tissue with absorption of the products of protein disintegration. Our own experience has been that there is usually an immediate fall in the platelet count after an operation other than splenectomy. A rather marked rise occurs after about the sixth post-operative day which is maintained for a week or ten days or even longer. Von Goidsenhoven,¹⁴¹ in reporting twelve cases of purpura hemorrhagica treated by ligation of the splenic artery, gives platelet counts before and after operation which also show a delayed rise in most cases. It would seem that other operations than splenectomy at least do not produce the immediate marked rise usually noted after removal of the spleen in patients.

It might be expected that by extirpation of the spleen, the surgeon was removing a pathological organ. Gregory⁶⁴ commonly finds a perisplenitis at operation and suggests that there is a primary infective lesion of the spleen. Leriche and Horrenberger⁹¹ assert that the splenic picture is one of infectious splenomegaly without specific characteristics. Kaznelson⁷² cites splenomegaly as evidence pointing to disease of the spleen in purpura hemorrhagica. On the other hand, MacCarty⁹⁸ has studied twenty spleens removed surgically because of purpura hemorrhagica. He says he has "not been able to distinguish this type of spleen from any normal spleen." The numerous reports from the literature fail to show any constant or characteristic histological changes in the spleen in purpura. That splenomegaly is not a characteristic finding is shown by McLean, *et al.*,⁹⁰ and by Stewart.¹³¹ McLean, Kreidel and Caffey were able to palpate the spleen in only five of their twenty-one children with purpura hemorrhagica. Stewart, in reviewing thirty-five cases reported, noted fifteen with enlarged or palpable spleens and eleven with non-palpable or normal spleens.

From the foregoing it must be concluded that although many operators have repeated the brilliant results obtained by Kaznelson in his cases of purpura hemorrhagica with splenectomy there is still no definite evidence that the spleen is the organ at fault in this disease. Clinical experience bears out the various experimental investigations to point toward a dysfunction of the whole hemopoietic system.

In spite of the fact that the spleen cannot be definitely incriminated as

the seat of the disease in purpura hemorrhagica, the good results which have followed its removal have led many surgeons to accept this method of treatment. There appears to be an almost universal agreement that splenectomy is indicated if the diagnosis is definitely established, and if the case is one of the chronic recurring type.

The diagnosis is made on the following points: (1) "Spontaneous extravasation of blood into or under the skin and mucous membranes of the body."¹¹⁷ (2) Diminished platelet count. (3) Prolonged bleeding time. (4) Approximately normal coagulation time. (5) Absence of clot retraction. (6) The appearance of petechia in the skin distal to a tourniquet blocking the venous but not the arterial flow. (7) Secondary anæmia without constant changes in the red blood-cells. (8) No constant variation in the white blood-cells, but usually an increase rather than a decrease.

Hitzrot⁹² points out that the differential diagnosis must be made from hemophilia and anaphylactic purpura. The diagnosis from hemophilia may be made on the basis of the non-traumatic origin of the bleeding, the lack of a familial history, the normal clotting time, the prolonged bleeding time, and the decrease in platelets. The anaphylactic type of purpura is usually associated with fever. It is preceded by premonitory symptoms and does not show the prolonged bleeding time or absence of clot retraction associated with purpura hemorrhagica.

In addition, the diagnosis must be made between purpura hemorrhagica and two other hemorrhagic diseases, acute aplastic anæmia and acute leukæmia. In acute aplastic anæmia with hæmorrhage, there is a marked diminution of all the former elements of the blood. There is an absence of reticulated red cells and usually a decided leukopenia whereas in purpura hemorrhagica a moderate leucocytosis is the rule. The acute leukæmia with a normal white blood count is perhaps the hardest differential diagnosis to make. The chief diagnostic point appears to be the relative marked increase of the young white cells in the blood in leukæmia. Several reports in the literature describe cases in which splenectomy was performed for purpura hemorrhagica in which there was later developed the typical picture of acute leukæmia.

With these diagnostic criteria in mind it may be well to consider the second point in the indications for splenectomy, *viz.*: the chronicity of the case. Whipple¹³⁰ classes as chronic those cases of purpura hemorrhagica having repeated attacks of petechia, purpuric areas, bleeding from the gums and menorrhagia in women. The bleeding is not usually very profuse and is not into the alimentary canal or into the parenchyma of organs. He is of the opinion that in these cases the major portion of the disturbance in the reticulo-endothelial system is in the spleen because splenectomy produces a cure. Splenectomy is therefore advised in the chronic case. In this opinion he is supported by Spence,¹²⁸ Fitz Hugh,⁸⁸ Jones,⁷¹ and many others. Williamson¹³⁸ limits his indications for splenectomy to his chronic cases in which the severity of the disease interferes with the normal life of the patient, making the patient a chronic invalid, or to those cases in which the severity and frequency of the hæmorrhages endanger the life of the patient.

The so-called acute purpura hemorrhagica is not so well defined in the literature. Some writers denote by the acute type the patient who suddenly begins to bleed without any previous history of hæmorrhage. Williamson¹³⁸ believes splenectomy is contra-indicated in the first attack, both on account of the uncertainty of the diagnosis and because of the unfavorable results.

Other authors such as Whipple¹³⁰ define the acute type as purpura hemorrhagica, occurring without any previous history of hæmorrhage, in which there is "sudden, severe, uncontrollable oozing of blood from mucous membranes and into the subcutaneous tissues and the internal organs." Hematemesis, hematuria, melæna and diffuse menor-

rhagia are characteristic symptoms. Whipple believes that such cases should be tided over by transfusions until the bleeding has stopped; and when built up, splenectomy to prevent recurrence. Still other writers designate those cases as acute in which there is uncontrollable severe hæmorrhage without reference to the number of previous attacks.

The opinions with regard to splenectomy in the so-called acute stage of the disease are varied. Fitz Hugh³⁵ and Jones⁷¹ give the clinician's view in expressing the opinion that splenectomy has seemed to only hasten the fatal outcome in the acute fulminating cases. Whipple¹³⁶ and Spence¹²⁸ on the basis of their case analyses believe splenectomy is definitely contra-indicated in these cases. Giffin,⁴⁶ Reuben and Claman,¹¹⁹ Rankin and Anderson,¹¹⁷ Cowen,¹⁰ Kerlin,⁷⁸ and Litchfield⁹⁵ all conclude that the acuteness of the hæmorrhage is not a safe guide as to whether splenectomy is indicated. These writers recognize that the results of splenectomy are much better in the chronic recurring type of purpura hemorrhagica with the hypertrophied spleen, but they hold to the view that even in the face of acute hæmorrhage, splenectomy should be performed if repeated transfusions fail to arrest bleeding, notwithstanding the fact that an occasional fatality may result. Maingot¹⁰⁵ is even more outspoken. He believes that splenectomy is the correct treatment for all cases of essential thrombopenic purpura hemorrhagica whether of the acute or of the chronic relapsing types. He maintains "that it is more urgently indicated for the acute types because medical treatment, blood transfusions, *etc.*, have no effect in arresting or even in ameliorating the factors which determine the fatal outcome."

A study of a group of cases of purpura hemorrhagica and of the literature on the subject leads to a view that the disease is one whose chief danger is from hæmorrhage, the exact etiological mechanism of which is not known. The disease tends to a spontaneous cure and recurrence as is characteristic of many of the blood dyscrasias. The therapeutic indications would appear to be, first, control of the hæmorrhage, and second, attempts to remove the etiological factors.

It would appear, therefore, that the treatment of hemorrhagica purpura cannot be divided into that for the acute type and that for the chronic type. The more logical consideration of the therapy would seem to be to employ first the most conservative method of treatment which removes the danger of immediate severe or recurrent hæmorrhage.

There can be no doubt that repeated transfusions may be effective in stopping the hæmorrhage and in producing a remission, often without subsequent recurrence, in many cases of purpura hemorrhagica. Larrabee,⁸⁰ Jones,⁶⁸ Krasso,⁸² Engel,⁸³ and Mofatt¹⁰³ report proven cases which support this view. McLean, *et al.*,⁶⁹ have recently reported eight patients, all children, treated by transfusion. Of these five acute and three chronic cases, there were no deaths, five were symptom free, four to fourteen months, and three were still under treatment.

Larrabee believes that a transfusion of 500 to 600 cubic centimetres of unmodified blood raises the platelet count 20,000. He thinks the effect is approximately one week in duration, the life of the platelets in the blood-stream. Although this may be a useful measure in many of the less severe cases, transfusion alone usually does not prove sufficient in most of the patients with extensive hæmorrhage. Other methods of controlling hæmorrhages in purpura should be mentioned in this connection. Many of them have proved successful in an occasional case but their very multitude suggests that they have not been universally effective. Calcium administration or an elevation of the blood calcium by parathormone is recommended by some authors.⁷¹ Dixon⁷⁷ reports four cases treated by intramuscular injections of twenty to thirty cubic centimetres of autogenous blood. Liver extract or a liver diet has been used with success by a few authors.^{71, 80} Pancoast, Pendergrass and Fitz Hugh¹⁰⁹ have reviewed the literature and reported their results with the Röntgen treatment of purpura. Ultra-violet radiation has been shown to effect an increase in the platelet count experimentally,¹³⁹ and this finding has been used clinically by Giffin,⁴⁴ Jones,⁷¹ McLean, *et al.*,⁶⁹ and many others.

A diet high in Vitamins B and C has been employed.^{44, 71} Thromboplastin injections have been given by many in the therapy of purpura.⁷¹ Antivenin injections have proved advantageous in other hands. The reports are increasing of the treatment of purpura with various forms of non-specific protein shock. Horse serum, milk, coagulen, peptone and even salvarsan have been given intramuscularly or intravenously with some reports of successful cases.^{39, 50, 108, 45} None of these methods appears to produce the rapid control of bleeding necessary in the patient with extensive hæmorrhage. The most effective method of producing an immediate or rapid hemostasis appears to be the removal of the spleen. Whether an etiological factor in the causation of purpura is thereby removed, or whether the tissue trauma incidental to the operation is the effective factor in raising the blood-platelets and in stopping the hæmorrhage, the fact remains that no other procedure gives such striking results. Our own experience has been similar to that of most other operators, that the previous uncontrollable bleeding often stops almost entirely within the first twenty-four to forty-eight hours after operation, coincidental with a sharp rise in the platelet count.

Uncontrollable bleeding, then, whether sudden and severe or recurrent, appears to be the indication for splenectomy in purpura hemorrhagica.

When should the operation be performed? The splenectomy should be performed before the patient has bled to such an extent as to be a poor operative risk, or after the patient has been prepared for operation by adequate blood transfusions. In some cases the hæmorrhage is so marked that a decision for operation must be made without delay. Anschütz² reports a case in which the hæmoglobin and red cells dropped from 85 per cent. and 4,100,000 to 45 per cent. and 2,460,000 in two hours. Immediate operation and transfusion saved the patient. In other instances less rapid but continuous bleeding may so deplete the patient as to make him a poor operative risk. In such cases repeated transfusions should be given until the hæmoglobin is returned to at least 50 per cent. (Marsh⁹⁷ points out that in six of the early fatal cases of splenectomy in "acute" purpura hemorrhagica the hæmoglobin and blood count were low, and that in all of the successful cases up to 1930 transfusions were given before operation.)

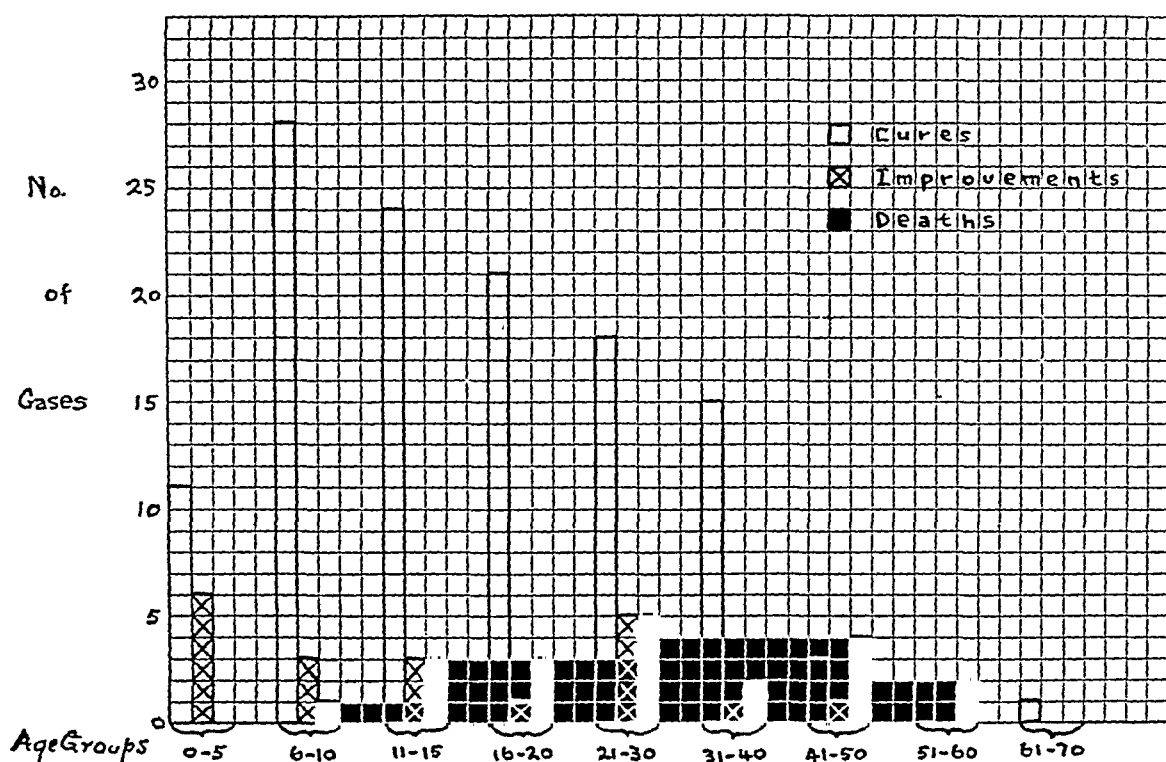
When the patient has been properly prepared, splenectomy may usually be performed without the danger of death from post-operative shock, the probable cause of the fatal outcome in many of the early cases.

The influence of the age of the patient at the time splenectomy is performed is frequently mentioned in the literature. Stewart,¹³¹ Anschütz,² and Washburn¹³⁵ agree that the results are more satisfactory in children than in adults, and Washburn suggests further that the prognosis after splenectomy is probably more favorable if the spleen is removed early in the course of the disease. These statements are in agreement with Gross's⁵⁵ findings that the spleen is most active in the young and least active in the old. It would seem that early splenectomy or splenectomy in the early years might be expected to give the best results if the spleen plays a part in the disease. (See chart.)

The second indication in the treatment of purpura hemorrhagica would appear to be to remove the etiological factors. This is truly a real problem at this time when there is no definite knowledge concerning the cause of the

SPLENECTOMY IN PURPURA HEMORRHAGICA

disease. However, it has been shown experimentally that purpura-like states, with marked reduction of the blood platelets, may be induced by the injection of diphtheria or other toxins.³⁰ Considerable literature is developing concerning the occurrence of purpura hemorrhagica after the injections of arsenicals in the treatment of syphilis.^{94, 68, 23, 134, 9, 11} Whipple¹³⁶ showed that in twelve of twenty-one children with purpura definite infections preceded the onset of the disease. He suggests that thrombocytopenia may be an allergic manifestation affecting particularly the megakaryocytes. Stewart¹³¹ points out that bacterial toxins may stimulate the reticulo-endothelial system to an increased destruction of platelets, and he believes it is important, therefore, to remove foci of infection in order to prevent recurrences.



Graph showing the frequency of purpura according to age in 163 patients. Note that there is a decrease in the number of cases in the older age groups and a relative increase in post-operative fatalities.

Giffin¹⁴ believes that splenectomy should be performed first before attempting to remove the focal infections and he concludes with the statement that he knows "of no instance in which recurrence of petechial or purpuric areas has persisted following careful elimination of foci."

The weight of evidence, therefore, points to some type of toxæmia as an etiological factor in production of purpura hemorrhagica. The logical prophylactic treatment is to remove the foci of infection after control of the hæmorrhage has been accomplished.

We are reporting herewith five cases of purpura with splenectomy, two of which were of the so-called acute type.

CASE I.—A. M. W., female, twelve years old, admitted to the service of Doctor Riesman, Philadelphia General Hospital, February 11, 1930. She complained of continuous bleeding from the nose since February 9, 1930. Packing did not control the

bleeding. There was slight oozing of blood from the navel and rather profuse bleeding from the gums. Ecchymoses were found under the conjunctiva, in the fundus of the eye and over the extremities. Many petechia were found in the skin and mucous membranes of the mouth. The skin showed a definite pallor. The Hess capillary resistance test was positive. The spleen was not palpable. Temperature, 98.6° ; pulse, 136; respirations, 24; blood-pressure, 102/40. Blood.—Red blood-cells, 1,800,000; hæmoglobin, 33 per cent.; reticulated red cells, 3 per cent.; white blood-cells, 10,500; polymorphonuclears, 80 per cent.; lymphocytes, 16 per cent.; mononuclears, 4 per cent. Platelets, 40,000. Bleeding time, thirteen minutes. The clot did not retract.

A diagnosis of thrombopenic purpura hemorrhagica was made. Two injections of ten cubic centimetres of thromboplastin were given. Nasal packing was inserted.

February 12, 1930.—Nasal packing changed. Röntgen deep therapy over spleen, 20 per cent. erythema dose. Transfusion 500 cubic centimetres citrated blood. Bleeding constantly.

February 13, 1930.—Temperature, 100° ; pulse, 140; respirations, 25. Continuous hæmorrhage from nose and gums. Vomiting blood. Patient rapidly growing weaker. 4 P.M.—Splenectomy, 500 cubic centimetres blood given by transfusion during the operation. The bleeding from the nose stopped during the operation and transfusion. Pulse at end of operation, 120. 10 P.M.—No further signs of hæmorrhage.

February 14, 1930.—No further hæmorrhage. Red blood-cells, 2,750,000; platelets, 160,000.

February 15, 1930.—Transfusion 300 cubic centimetres citrated blood.

February 16, 1930.—Slight bleeding from nose for short time after child had "picked" her nose.

February 17, 1930.—Red blood-cells, 3,550,000; hæmoglobin, 63 per cent.; white blood-cells, 18,000; platelets, 125,000.

February 24, 1930.—Red blood-cells, 3,460,000; hæmoglobin, 65 per cent.; white blood-cells, 8,400; platelets, 120,000.

March 9, 1930.—Wound healed. No further bleeding. Patient discharged. Red blood-cells, 3,500,000; platelets, 160,000.

June 11, 1930.—No recurrence of bleeding. Patient has gained much weight. Red blood-cells, 5,530,000; hæmoglobin, 100 per cent.; white blood-cells, 17,700; platelets, 70,000.

December 3, 1930.—Symptom-free. No recurrence of bleeding. Weight, $116\frac{1}{2}$ pounds. Red blood-cells, 4,610,000; hæmoglobin, 100 per cent.; white blood-cells, 13,850; platelets, 230,000.

June 20, 1931.—No recurrence. Weight $125\frac{1}{2}$ pounds. Red blood-cells, 4,310,000; white blood-cells, 12,400; hæmoglobin, 90 per cent.; platelets, 100,000.

May 10, 1932.—No recurrence. Weight 154 pounds. Bleeding time, two minutes. Red blood-cells, 4,550,000; white blood-cells, 13,600; hæmoglobin, 90 per cent.; platelets, 260,000.

CASE II.—M. G., male, seven years old, admitted to Doctor Lowenburg's service at the Mt. Sinai Hospital, Philadelphia, June 16, 1930, complaining of "blue marks on the body." He had noticed the spots for about three years and they did not always follow trauma. Until his tonsillectomy three years before admission he had had frequent cold and "sore throat." Temperature, 99.6° ; pulse, 90. The child was markedly emaciated. The cervical glands were enlarged. There were submucous hæmorrhages on his cheeks, tongue, and pharynx, and multiple petechia and ecchymoses on the trunk and extremities. The spleen was just palpable. Blood.—Red blood-cells, 4,700,000; hæmoglobin, 80 per cent.; platelets, 250,000. Coagulating time, $4\frac{1}{2}$ minutes. Bleeding time, $19\frac{3}{8}$ minutes. Friable, non-retracted clot after twenty-four hours.

July 3, 1930.—Bleeding not marked but has not entirely stopped. Red blood-cells,

SPLENECTOMY IN PURPURA HEMORRHAGICA

4,490,000; hæmoglobin, 80 per cent.; platelets, 140,000. Bleeding time, thirty-one minutes.

July 10, 1930.—Splenectomy.

July 31, 1930.—Recovery uneventful. All bleeding ceased. Discharged. Platelets, 210,000. Bleeding time, 2½ minutes. Solid retracted clot.

January, 1931.—Purpuric spots reappeared and bleeding from gums was noted.

February 17, 1931.—Readmitted. Red blood-cells, 4,490,000; hæmoglobin, 80 per cent. Coagulation time, five minutes. Bleeding time, nine minutes. Platelets, 160,000.

February 23, 1931.—Blood transfusion. Ultra-violet light exposure. Petechia appeared on extremities and chest after confusion. March 3, 1931.—Petechia clearing up. Platelets, 130,000. Calcium gluconate daily. March 23, 1931.—Improving. Bleeding time, 2 1/3 minutes. Platelets, 140,000. March 28, 1931.—Discharged.

April 28, 1931.—No bleeding since discharge from hospital but his mother says "he bruises easily." Red blood-cells, 4,780,000; hæmoglobin, 85 per cent.; white blood-cells, 14,700; polymorphonuclears, 70 per cent.; lymphocytes, 29 per cent.; large mononuclears, 1 per cent. Coagulation time, three minutes. Bleeding time, eighteen minutes. Platelets, 120,000. No solid clot after eighteen hours at 37° C. This patient suffers from frequent upper respiratory infections and probably has a focus of infection in the nose or sinuses, which has not been cleared up.

CASE III.—R. C., female, thirty-three years old, was admitted to the service of Doctor Jump at the Philadelphia General Hospital, April 17, 1931, complaining of bleeding from the gums and vagina. For the past four years her periods had gradually become more profuse. In December, 1930, she was forced to stop her work because of bleeding from mucous membranes. Since April 10, 1931, she had bled from the gums and vagina. She was so weak that she had to come to the hospital. She gave a history of rheumatism in 1923 and of profuse bleeding following the extraction of teeth. There was no familial tendency to bleed. There was continuous bleeding from the gums and large areas of submucous hæmorrhage on the tongue and mucosa of the mouth. The nose contained clots. Petechia were evident in the mucous membranes, conjunctiva and skin. The vagina was pale. There were several hæmorrhagic areas on the labia. When the labia were separated about two ounces of liquid blood escaped. The uterus and vagina failed to show any ulcerations or neoplasm. Large ecchymotic areas were found on the right thigh. Red blood-cells, 2,040,000; hæmoglobin, 30 per cent.; white blood-cells, 7,400; platelets, 40,000. Coagulation time, four minutes. Bleeding time, fifteen minutes +.

April 18, 1931.—450 (c.c.) citrated blood by transfusion. Antivenin ten cubic centimetres intravenously and ten cubic centimetres intramuscularly. Calcium lactate given by mouth in large doses. Bleeding not checked by these measures.

April 20, 1931.—Red blood-cells, 1,900,000; hæmoglobin, 31 per cent.; white blood-cells, 7,900; platelets, 40,000. Bleeding has decreased. April 23, 1931.—Bleeding stopped entirely. Red blood-cells.—1,190,000; hæmoglobin, 30 per cent.; white blood-cells, 16,900; platelets, 320,000.

May 3, 1931.—No further bleeding. Red blood-cells, 2,140,000; hæmoglobin, 40 per cent.; white blood-cells, 9,700; platelets, 350,000.

May 10, 1931.—Bleeding began again from gums. Thromboplastin, twelve cubic centimetres intramuscularly.

May 11, 1931.—Bleeding from gums, nose and vagina. Red blood-cells, 2,380,000; hæmoglobin, 50 per cent.; platelets, 80,000. Bleeding time, twenty-seven minutes. Patient desensitized to antivenin and given ten cubic centimetres intramuscularly.

May 12, 1931.—Profuse bleeding continues. Splenectomy and transfusion.

May 13, 1931.—Bleeding from mucous membranes has stopped. Red blood-cells, 2,640,000; white blood-cells, 17,600; platelets, 210,000. Bleeding time, five minutes.

May 14, 1931.—Slight vaginal bleeding, may be old blood. Red blood-cells, 1,420,000; hæmoglobin, 35 per cent.; platelets, 350,000. Bleeding time, three minutes.

May 17, 1931.—No further bleeding. Purpuric areas are disappearing. May 25, 1931.—Bleeding time, one minute. June 4, 1931.—No further bleeding. Red blood-cells, 3,170,000; platelets, 350,000. We have been unable to locate this patient.

CASE IV.—M. T., male, aged twenty years, was admitted to the service of Doctor Stengel, University Hospital, Philadelphia, February 6, 1931, complaining of bleeding from nose. He has had frequent nose bleeds since he was ten years old. His present attack began one week before his admission and could not be controlled by nasal packing. He had never noted any unusual bleeding from cuts or bruises and there was no familial history of bleeding. At the time he was examined there was continuous bleeding from his nose and gums, and petechia were evident in the skin and mucous membranes. Red blood-cells, 3,300,000; white blood-cells, 24,000; hæmoglobin, 56 per cent.; platelets, too few to count. Bleeding time, 2½ minutes. Coagulation time, five minutes. Slightly retracted clot in twenty-four hours. Tourniquet test, positive.

February 7, 1931.—Patient developed an otitis media of the right ear from which pus is draining.

February 10, 1931.—Still bleeding. Transfusion 500 cubic centimetres citrated blood, fifty cubic centimetres whole blood injected intramuscularly. Platelets, 16,000.

February 11, 1931.—Splenectomy and transfusion. Platelets, 9,200. February 12, 1931.—Still oozing slightly from the nose. Transfusion 500 cubic centimetres.

February 16, 1931.—Slight bleeding from nose. Platelets, 15,000. Bleeding time, 2½ minutes. Slight clot retraction. Transfusion 350 cubic centimetres.

February 28, 1931.—Transfusion 500 cubic centimetres. Still slight bleeding from nose. March 13, 1931.—Platelets, 51,200. Still same ooze from right nostril. Ear is improved. March 23, 1931.—Violent nose bleed today. Platelets, 3,000. Antivenin given intramuscularly. March 26, 1931.—Nasal bleeding slight. Petechia have appeared in the skin of the trunk and extremities. Platelets, 57,600. April 7, 1931.—Patient has had slight bleeding from the nose for past five days. Platelets, 48,000. April 20, 1931.—No bleeding. Patient signed his release from hospital. Platelets, 16,800. May 18, 1931.—No further bleeding. Platelets, 22,400.

May 8, 1932.—Slight epistaxis on two occasions. Working daily. Red blood-cells, 5,100,000; hæmoglobin, 90 per cent.; white blood-cells, 6,800; platelets, 110,400. Bleeding time, one minute.

CASE V.—R. V., male, aged two years, seven months, was admitted September 30, 1931, to the Pædiatric Service, University Hospital, Philadelphia, complaining of blue marks on the skin. He had been normal until the week before admission when bluish spots appeared on the epigastrium and on the legs. Petechia were present on the face and neck. There was a small subconjunctival hæmorrhage in the left eye. The teeth were markedly carious. Hæmorrhages were noted in the hard and soft palate. Red blood-cells, 4,800,000; hæmoglobin, 75 per cent.; white blood-cells, 15,000; platelets, 2,500. Bleeding time, one hour. Clotting time, seven minutes. No clot retraction in seventeen hours.

October 2, 1931.—Platelets, 3,200. Transfusion, 200 cubic centimetres. Platelets after transfusion, 8,000. October 3, 1931.—Platelets, 28,000. Some blood in stool. October 5, 1931.—Platelets, 18,000. Transfusion, 140 cubic centimetres. Large purpuric area on the lateral aspect of left thigh. Whole blood five cubic centimetres given intramuscularly every third day. October 7, 1931.—Platelets, 12,800; red blood-cells, 4,000,000; hæmoglobin, 100 per cent.

October 9, 1931.—Splenectomy. Spleen very small. Transfusion 100 cubic centimetres. Post-operative blood, red blood-cells, 5,200,000; white blood-cells, 41,400; hæmoglobin, 90 per cent.; Platelets, 38,400. October 10, 1931.—Platelets, 234,000. October 12, 1931.—Platelets, 896,000. October 14, 1931.—Platelets, 540,000. October

SPLENECTOMY IN PURPURA HEMORRHAGICA

22, 1931.—Platelets, 326,000. November 4, 1931.—Platelets, 672,000. Bleeding time, 2½ minutes. No further bleeding since operation. Discharged.

November, 1931.—Tonsillectomy and teeth extraction. No undue bleeding. April 27, 1932.—No bleeding since operation. Patient has gained eight pounds in weight. Red blood-cells, 4,000,000; hæmoglobin, 78 per cent.; white blood-cells, 11,900; platelets, 330,000. Bleeding time, 1½ minutes. Clot retractility, normal. Clotting time, ten minutes.

In order to have some basis on which to judge the results and dangers of splenectomy in purpura hemorrhagica we have collected and analyzed all of the cases we were able to find in the literature up to 1932. The two previous analyses of cases were those of Whipple in 1926¹³⁶ of eighty-one cases and of Spence in 1928¹²⁸ of 101 cases. In Spence's report the case of Farley and of Lee is the same patient making 100 cases reported by Spence. He also included all but five of Whipple's eighty-one cases, so that the combined reports of Whipple and Spence contain 105 individual cases. We have collected an additional 103 cases from the literature and are adding five unreported cases of our own, making a total of 213 cases upon which our analysis has been made. The data have not always been available for a complete analysis and in such instances the figures given are based on the cases in which the significant data have been found.

The cases have been divided into the conventional chronic and acute types in order that our figures may be comparable to the previous reports. Of the 213 cases, thirty-five were classified as acute, 160 as chronic and in eighteen cases it was impossible to classify the type of purpura.

Results.—Of the 213 patients, twenty-eight died as a result of or shortly after operation, a mortality for the whole group of 13.1 per cent. Spence reported 100 cases with twenty deaths, a mortality of 20 per cent. In the 113 additional cases there were only eight deaths, a reduction in the period 1928 to 1932 to 7.08 per cent. The results in the remaining patients may be classified as follows:

"Cures"	156 cases	73.2%
Improved	17 cases	8.0%
Unimproved	6 cases	2.8%
Result unknown	6 cases	2.8%

Cases were classified as cured if they had recovered from their operations and had no further bleeding up to the time when the report was made. This may not be a true picture of the results because at least forty-seven cases were reported within six months from the time of operation, and twenty-eight more between six months and a year after splenectomy. The remaining cases were reported as follows:

1 to 2 years after splenectomy	26 cases
2 to 3 years after splenectomy	12 cases
3 to 4 years after splenectomy	3 cases
4 to 5 years after splenectomy	12 cases
Over 5 years after splenectomy	5 cases
Unknown time after splenectomy	24 cases

ELIASON AND FERGUSON

To date there have been no large series of cases reported from which it is possible to evaluate the five-year results.

Results in Acute Purpura Hemorrhagica

Acute purpura	35 cases		
Cures	22 cases	}	65.7%
Improvement	1 case		
Deaths	12 cases		34.3%

These figures are at variance with those of Whipple and Spence. Whipple reported seven deaths in the eight cases of acute purpura with splenectomy, and Spence found ten deaths in twelve cases operated upon, a mortality of 83.3 per cent. Since his report there have been twenty-two cases of acute purpura with only three deaths, a mortality of only 13.6 per cent. in the cases reported since 1928. This figure approaches the mortality figures in chronic purpura. It is probable that the decrease in mortality noted in the above figures may be attributed to a tendency to earlier splenectomy and especially to an improvement in the preparation of these patients for operation.

Results in Chronic Purpura Hemorrhagica

Chronic purpura	160 cases		
Cures	124 cases—77.5%	}	88.1%
Improved	17 cases—10.6%		
Unimproved	4 cases— 2.5%		
Deaths	11 cases— 7.0%		
No follow-up	4 cases— 2.5%		

In Whipple's report there were seventy-three chronic cases, of which six died, a mortality of 8.2 per cent. Spence found a mortality of 11.8 per cent. There has been, therefore, also a reduction in the mortality figures for splenectomy in chronic purpura during the period 1928 to 1932.

Results in Unclassified Purpura Hemorrhagica

Total cases	18
Cures	10 cases—55.5%
Improved	1 case
Deaths	5 cases—27.8%
No follow-up	2 cases

If it were possible to accurately classify these cases, it would naturally increase slightly the mortality figures for the so-called acute and chronic cases.

In investigating the cause of death, it was found that all but one of the acute cases died either on the operating table or on the day of operation. There was one patient who lived until the tenth post-operative day. The factor of delay in operation, and markedly decreased red blood-cells and hæmoglobin was evident in all but two cases, and in these cases the last blood studies given were those several days or more before operation, so that it is probable that these patients too were well bled out at the time of operation.

The deaths in the so-called chronic cases may be grouped under four chief heads: Operative shock, delayed operation, three cases; post-operative intracranial hæmorrhage, three cases; operative accident or post-operative complications, three cases; splenectomy in atypical cases, two cases. Both of the latter cases died some time after operation with the typical picture of aleukæmic leukæmia.

The cases of unclassified purpura died from the same causes: three from operative shock, one three months after operation and from myelogenous leukæmia, and one from cerebral hæmorrhage. In summarizing the causes of death after splenectomy for purpura hemorrhagica, it appears that the most frequent factor is a controllable one, post-operative shock in an anæmic patient. This cause of death appeared evident in eighteen of the twenty-eight fatal cases. Intracranial hæmorrhage led to a fatality in four cases. Operative accidents or complications occurred in three cases and in three cases there was probably an error in diagnosis.

SUMMARY

(1) A review of the literature points to the fact that purpura hemorrhagica is a disease causing not only a reduction of blood-platelets but also a disturbance of the entire reticulo-endothelial system.

(2) It has not yet been proven that the spleen is the organ at fault in purpura hemorrhagica.

(3) A definitely established diagnosis must be made before splenectomy should be considered.

(4) Once the diagnosis is established, the therapeutic indications appear to be (1) control of hæmorrhage, (2) removal of etiological factors.

(5) Splenectomy appears to be the most effective method of controlling extensive hæmorrhage in purpura hemorrhagica of either the acute or recurring type.

(6) Early operation and adequate preparation of the patient by transfusion is imperative.

(7) Removal of foci of infection is the best prophylaxis against recurrences.

(8) Five additional cases of purpura hemorrhagica with splenectomy are reported.

(9) A review of the results obtained in 213 reported cases has been made.

(10) The operative mortality for the whole group was 13.1 per cent. but in the cases collected from the last four years the mortality is only 7.08 per cent. in 113 cases.

(11) In acute purpura, there were thirty-five cases treated by splenectomy with twelve deaths, 34.3 per cent. In the last twenty-two cases there were only three deaths, 13.6 per cent.

(12) In the chronic purpuras there were 160 cases with eleven deaths, 7 per cent.

(13) In eighteen of the twenty-eight cases the cause of death appeared to be post-operative shock in a poor-risk patient; less frequent causes were intracranial hæmorrhage, operative accidents or post-operative complications or incorrect diagnoses.

(14) One hundred eight cases are collected and analyzed.

SUMMARIES OF REPORTED CASES OF SPLENECTOMY FOR THROMBOCYTOPENIC
PURPURA HEMORRHAGICA

*(Not including the eighty-one cases reported by Whipple in 1926
or the 101 cases reported by Spence in 1928)*

CASE I by Fitz Hugh,³⁷ 1925. Female, eight years, chronic (three months). Red blood-cells, 3,600,000; hæmoglobin, 52 per cent.; bleeding time, 8 to 30 minutes; platelets, 6,000 to 30,000. X-radiation and sterilized-milk injections did not produce remission. After splenectomy, bleeding time, 1¾ minutes; platelets, 74,000 to 273,000. No further bleeding but clot remained non-retractile. Reported four months after splenectomy. Cure.

CASE II by Beer,⁷ 1926. Male, fifteen years, chronic (3½ years). Red blood-cells, 2,010,000; hæmoglobin, 28 per cent.; bleeding time, 4½ minutes; platelets, 10,000 to 24,000. X-radiation and transfusions before operation. After splenectomy, bleeding time, three minutes; platelets, 22,000 to 4,000. Slight oozing from wound stopped on tenth post-operative day. Retraction of clot returned. Reported four years after splenectomy. Cure.

CASE III by Beer,⁷ 1926. Female, seventeen years, chronic (nine months). Red blood-cells, 5,120,000 to 2,010,000; hæmoglobin, 94 to 69 per cent.; bleeding time, forty-two minutes; platelets, 10,000. Transfusions and radiotherapy before operation. After splenectomy, bleeding time, seven to two minutes; platelets, 12,000 to 80,000. Bleeding from uterus two weeks after operation. Checked by radiotherapy. Reported two years after splenectomy. Cure.

CASE IV by Beer,⁷ 1926. Male, eighteen years, chronic (2½ months). Red blood-cells, 3,840,000; hæmoglobin, 76 per cent.; bleeding time, fourteen minutes; platelets, 5,000. After splenectomy, bleeding time, 2½ minutes; platelets, 130,000. Patient in perfect health. Reported seven months after splenectomy. Cure.

CASE V by Beer,⁷ 1926. Male, thirteen years, chronic (four weeks). Red blood-cells, 3,472,000; hæmoglobin, 67 per cent.; bleeding time, ten minutes; platelets, 20,000. After splenectomy, bleeding time (?); platelets, 550,000. Patient in excellent health. Reported five months after splenectomy. Cure.

CASE VI by Beer,⁷ 1926. Female, twenty-two years, chronic (six months). Red blood-cells, 1,168,000; hæmoglobin, 22 to 33 per cent.; bleeding time, ten minutes; platelets, 2,500. Transfusions before operation. After splenectomy, bleeding time (?), platelets (?). Died three hours after operation. No autopsy. Death.

CASE VII by Falconer and McLachlan,³⁵ 1926. Female, ten years, chronic (three months). Red blood-cells, (?); hæmoglobin, (?); bleeding time, prolonged; platelets, occasional. Thrombin injections, calcium lactate, intravenous afenil, transfusions. After splenectomy, bleeding time, (?); platelets, (?). No bleeding after operation. Reported two months after splenectomy. Cure.

CASE VIII by Falconer and McLachlan,³⁵ 1926. Female, twenty-eight years, chronic (eight months). Red blood-cells, 800,000; hæmoglobin, (?); bleeding time, eleven to fifteen minutes; platelets, scanty. Transfusions before operation. After splenectomy, bleeding time, four minutes; platelets—no apparent increase found. Clinically cured. Death followed spontaneous delivery of stillborn child two months after operation. Reported two months after splenectomy. Cure (?).

CASE IX by Harris,⁵⁶ 1926. Female, eleven years, chronic (three years). Red blood-cells, 3,880,000 to 3,260,000; hæmoglobin, 85 to 75 per cent.; bleeding time, twenty-five to thirty minutes; platelets, 12,500 to 16,600. Packing, transfusion and tampon

before operation. After splenectomy, bleeding time, two to six minutes; platelets, 595,000 to 504,000. No recurrence. Reported eight months after splenectomy. Cure.

CASE X by Hodges,⁶³ 1926. Female, fifteen years, chronic (one year). Red blood-cells, 3,970,000 to 5,000,000; hæmoglobin, 55 to 85 per cent.; bleeding time, twelve minutes; platelets, 40,000 to 16,000. Transfusion before operation. After splenectomy, bleeding time, four minutes; platelets, 198,000 to 1,200,000. Periods reëstablished normally. Reported one year after operation. Cure.

CASE XI by Kerlin,⁷⁷ 1926. Female, fourteen years, chronic (seven years). Red blood-cells, 1,240,000 to 2,730,000; hæmoglobin, 65 to 40 per cent.; bleeding time, five minutes; platelets, 35,000 to 40,000. D and C, radium, transfusions before operation. After splenectomy, bleeding time, four minutes; platelets, 40,000 to 160,000. Patient gaining weight and strength. Reported one year after splenectomy. Cure.

CASE XII by Reilingh,¹¹⁸ 1926. Female, forty-nine years, chronic (2½ years). Red blood-cells, (?); hæmoglobin, (?); bleeding time, (?); platelets, (?). Calcium chloride, peptone before operation. After splenectomy, bleeding time, (?); platelets, 24,000 to 1,017,000. No post-operative hæmorrhages. Reported five months after operation. Cure.

CASE XIII by Crawford and Ogilvie,²⁰ 1927. Female, seven and one-half years, chronic (two years, one month). Red blood-cells, 2,500,000 to 3,400,000; hæmoglobin, 25 per cent.; bleeding time, thirty to twenty minutes; platelets, 7,700 to 3,000. Transfusions, horse serum (intramuscular), tonsillectomy, before operation. After splenectomy, bleeding time, four to seven to six minutes; platelets, 40,000 to 21,000. Patient well six months after operation. Reported six months after splenectomy. Cure.

CASE XIV by Crawford and Ogilvie,²⁰ 1927. Female, seven years, chronic (five months). Red blood-cells, 4,500,000; hæmoglobin, 80 per cent.; bleeding time, twelve minutes; platelets, 22,000. Transfusions before operation. After splenectomy, bleeding time, 0 to two minutes; platelets, 800,000 to 1,500,000 to 200,000. No purpura since operation. Reported four months after splenectomy. Cure.

CASE XV by De Leeuw,²¹ 1927. Sex (?), thirty-six years, chronic (twenty-two years). Red blood-cells, 1,600,000; hæmoglobin, 63 per cent.; bleeding time, eight minutes; platelets, 3,800. Transfusions before operation. After splenectomy, bleeding time, 3½ to 4 minutes; platelets, 190,000. Cure.

CASE XVI by Marin,⁹⁰ 1927. Male, eleven years, chronic (eight years). Red blood-cells, 3,500,000; hæmoglobin, 75 to 40 per cent.; bleeding time, twenty-five to thirty minutes; platelets, 25,000 to 15,000. After splenectomy, bleeding time, 1 to 3½ minutes; platelets, 880,000 to 250,000. Cure.

CASE XVII by Muller,¹⁰⁴ 1927. Female, twenty-six years, chronic (four months). Red blood-cells, (?); hæmoglobin, (?); bleeding time, (?); platelets, 10,000 to 30,000. After splenectomy, bleeding time, (?); platelets, 100,000. Reported two years after splenectomy. Cure.

CASE XVIII by Muller,¹⁰⁴ 1927. Female, twenty-six years, chronic (fifteen years). Red blood-cells, (?); hæmoglobin, (?); bleeding time, (?); platelets, 5,000. After splenectomy, bleeding time, (?); platelets, 160,000. Reported six years after splenectomy. Cure.

CASE XIX by Narog,¹⁰⁰ 1927. Male, eighteen years. Cure.

CASE XX by Schaack,¹²³ 1927. Female, nineteen years, chronic (six years). Red blood-cells, 4,000,000 to 4,500,000; hæmoglobin, 40 per cent.; bleeding time, twenty-seven minutes; platelets, few. After splenectomy, bleeding time, (?); platelets, 125,000 to 568,000. Next period normal. Cure.

CASE XXI by Schaak,¹²⁵ 1927. Female, thirty-five years, chronic (twenty years). Red blood-cells, 3,000,000 to 4,000,000; hæmoglobin, 40 to 75 per cent.; bleeding time, prolonged; platelets, 8,000. Gelatinum, ergotin, calcium solutions before operation. After splenectomy, bleeding time, three minutes; platelets, 300,000 to 92,000. Patient well. Reported six months after splenectomy. Cure.

CASE XXII by Schaak,¹²⁵ 1927. Female, twenty-eight years, chronic (thirteen years). Red blood-cells, 3,000,000 to 4,500,000; hæmoglobin, 60 to 70 per cent.; bleeding time, twenty to thirty minutes; platelets, 1,000 to 2,000. Protein therapy, X-ray. Eight months in bed. Gelatinum, calcium before splenectomy. After splenectomy, bleeding time, 4 to 4½ minutes; platelets, 115,000 to 400,000. Patient well. Reported two months after splenectomy. Cure.

CASE XXIII by Ceballos and Taubenschlag,¹⁰ 1928. Female, thirty-two years, acute (nine days). Red blood-cells, 2,440,000; hæmoglobin, 34 per cent.; bleeding time, prolonged; platelets, none. Sulpharsenol, lavages, serum, propidon, transfusion before operation. After splenectomy, bleeding time, (?); platelets, normal. Hæmorrhages not repeated after operation. Reported 1½ years after splenectomy. Cure.

CASE XXIV by Emil-Weil and Grégoire,³¹ 1928. Sex, (?), thirty-one years, chronic (nineteen years). Red blood-cells, 1,883,000 to 4,800,000; hæmoglobin, 85 per cent.; bleeding time, four to twenty-nine minutes; platelets, (?). Transfusions, nasal packing before operation. After splenectomy, bleeding time, 1½ to 6 minutes; platelets, 210,000. Patient in good condition. Reported four months after splenectomy. Cure.

CASE XXV by Gosset, Chevalier and Gutmann,⁴⁵ 1928. Female, age, (?), chronic (thirteen years). Red blood-cells, 2,305,000; hæmoglobin, 40 per cent.; bleeding time, sixteen to thirty minutes; platelets, 180,000. X-ray of long bones before operation. After splenectomy, bleeding time, 2½ to 2 minutes; platelets, 264,000 to 237,000. Bleeding stopped first day. Patient has few nose-bleeds when tired. Cure.

CASE XXVI by Green,⁵¹ 1928. Female, thirty-nine years, chronic (four years). Red blood-cells, 2,000,000 to 4,200,000; hæmoglobin, 48 to 82 per cent.; bleeding time, two minutes; platelets, 70,000 to 500,000. Transfusions and ultra-violet before operation. After splenectomy, bleeding time, two minutes; platelets, 800,000. Epistaxis seven days after operation. Result, unknown.

CASE XXVII by Gregory,⁵⁴ 1928. Male, aged seven, chronic (two years). Red blood-cells, 1,765,000; hæmoglobin, 25 per cent.; bleeding time, fifteen minutes; platelets, 47,700. Transfusions before operation. After splenectomy, bleeding time, 20 to 4½ minutes; platelets, 150,000 to 120,000. Patient had one small epistaxis during convalescence and two since. Reported ten months after splenectomy. Improvement.

CASE XXVIII by Jones, H. C.,⁷⁰ 1928. Female, thirty-three years, chronic (six months). Red blood-cells, 2,150,000; hæmoglobin, 21 per cent.; bleeding time, 23½ to six to eighteen minutes; platelets, 100,000 to 211,000. Transfusions before operation. After splenectomy, bleeding time, five minutes; platelets, 352,000 to 552,000. Patient well. Reported one year after splenectomy. Cure.

CASE XXIX by Kennedy,⁷⁰ 1928. Female, eleven years, chronic (five years). Red blood-cells, (?); hæmoglobin, (?); bleeding time, sixty minutes; platelets, 46,000. After splenectomy, bleeding time, five minutes; platelets, 430,000 to 50,000. Patient had slight epistaxis six weeks after operation. Condition good. Reported four years after splenectomy. Cure.

CASE XXX by Kennedy,⁷⁰ 1928. Female, eleven years, chronic (5½ years). Red blood-cells, (?); hæmoglobin, (?); bleeding time, eleven minutes; platelets, 98,000. After splenectomy, bleeding time, three minutes; platelets, 640,000 to 296,000. Condition excellent. Reported four years after splenectomy. Cure.

CASE XXXI by Kennedy,⁷⁰ 1928. Female, six years, acute (three weeks). Red blood-cells, (?); hæmoglobin, (?); bleeding time, ninety minutes; platelets, 44,000. After splenectomy, bleeding time, three minutes; platelets, 316,000 to 280,000. Condition excellent. Reported three years after splenectomy. Cure.

CASE XXXII by Kennedy,⁷⁰ 1928. Male, ten years, chronic (eight months). Red blood-cells, (?); hæmoglobin, (?); bleeding time, sixty minutes; platelets, 56,000. After splenectomy, bleeding time, (?); platelets, 372,000. Condition excellent. Reported two years after splenectomy. Cure.

CASE XXXIII by Kennedy,⁷⁰ 1928. Male, nine years, chronic (three years). Red blood-cells, (?); hæmoglobin, (?); bleeding time, eighteen minutes; platelets, 36,000. After splenectomy, bleeding time, (?); platelets, (?). Condition excellent. Reported two years after splenectomy. Cure.

CASE XXXIV by Kennedy,⁷⁰ 1928. Male, four and one-half years, chronic (seven weeks). Red blood-cells, (?); hæmoglobin, (?); bleeding time, forty-eight minutes; platelets, 50,000. After splenectomy, bleeding time, (?); platelets, 328,000 to 120,000. No recurrence. Reported six months after splenectomy. Cure.

CASE XXXV by Kennedy,⁷⁰ 1928. Female, eight and one-half years, chronic (four months). Red blood-cells, (?); hæmoglobin, (?); bleeding time, twenty minutes; platelets, 64,000. After splenectomy, bleeding time, two minutes; platelets, 224,000 to 258,000. No recurrence. Reported two years after splenectomy. Cure.

CASE XXXVI by Kennedy,⁷⁰ 1928. Female, seven years, chronic (two years). Red blood-cells, (?); hæmoglobin, (?); bleeding time, twenty-eight minutes; platelets, 144,000. After splenectomy, bleeding time, twenty-eight minutes; platelets, 242,000 to 208,000. Condition excellent. Reported two years after splenectomy. Cure.

CASE XXXVII by Kennedy,⁷⁰ 1928. Female, nine years, chronic (seven and one-half years). Red blood-cells, (?); hæmoglobin, (?); bleeding time, sixty minutes; platelets, 300,000. After splenectomy, bleeding time, 120 minutes; platelets, 352,000 to 272,000. No epistaxis or purpura following operation. Patient menstruates profusely. Reported four years after splenectomy. Cure.

CASE XXXVIII by Kennedy,⁷⁰ 1928. Female, four years, acute (one week). Red blood-cells, (?); hæmoglobin, (?); bleeding time, twenty-six minutes; platelets, 98,000. After operation, bleeding time, thirteen minutes; platelets, 208,000 to 88,000. No improvement following operation. Death followed tonsillectomy two months later. Unimproved.

CASE XXXIX by Lesne, Marquezy and Stieffel,⁹² 1928. Female, twenty-three years, chronic (sixteen years). Red blood-cells, 3,400,000; hæmoglobin, 70 per cent.; bleeding time, seventeen minutes to three hours; platelets, 50,000. Hospitalized many times, radiotherapy, serum, anthema, peptone, calcium chloride, thyroid and ovarian extract. After splenectomy, bleeding time, nine to five to thirty minutes; platelets, 200,000 to 50,000. Purpura one month after operation. One epistaxis requiring packing. Judgment reserved. Reported one year after splenectomy. Improvement.

CASE XL by Merklen and Leriche,¹⁰⁰ 1928. Female, seventeen years, chronic (eight months). Red blood-cells, 1,480,000; hæmoglobin, 26 per cent.; bleeding time, forty minutes; platelets, 26,000 to 28,000. Transfusions, irradiations of spleen, coagulen before operation. After splenectomy, bleeding time, four to twenty-one to seven minutes; platelets, 18,200 to 200,000. No bleeding following operation. Reported six months after splenectomy. Cure.

CASE XLI by Pinkerton,¹¹⁰ 1928. Female, eighteen years, chronic (four months). Red blood-cells, 1,080,000; hæmoglobin, 20 per cent.; bleeding time, thirty minutes; platelets, 18,000. Transfusion, nasal packing, hemostatics before operation. After splenectomy, bleeding time, 2½ minutes; platelets, 80,000 to 20,000. Purpuric spots on ankle twelfth day. Trace of blood from gums fifth and twelfth days. Otherwise uneventful convalescence. Reported four months after splenectomy. Cure.

CASE XLII by Reuben and Claman,¹¹⁰ 1928. Female, three and one-half years, acute (three days). Red blood-cells, 3,200,000 to 2,700,000; hæmoglobin, 73 to 48 per cent.; bleeding time, prolonged; platelets, 55,000 to 10,000. Transfusions before operation. After splenectomy, bleeding time, (?); platelets, 68,000 to 590,000. Patient operated upon for acute mastoiditis following splenectomy and complete healing took one year. Now well in every respect. Reported eighteen months after splenectomy. Cure.

CASE XLIII by Reuben and Claman,¹¹⁰ 1928. Male, six and one-half years, chronic (three months). Red blood-cells, 4,500,000; hæmoglobin, 70 per cent.; bleeding time, fifteen minutes; platelets, 78,000. Transfusions, alpine treatments, milk injections,

adrenalin before operation. After splenectomy, bleeding time, (?); platelets, 385,000 to 487,000. No recurrence. Reported four months after splenectomy. Cure.

CASE XLIV by Reuben and Claman,¹¹⁰ 1928. Female, nine and one-half years, acute (nine days). Red blood-cells, 3,500,000; bleeding time, twenty minutes; platelets, 40,000 to 50,000. "All medical measures," transfusions before splenectomy. After splenectomy, bleeding time, $3\frac{1}{2}$ to 45 to 17 minutes; platelets, 43,000—few. Patient clinically cured but still has thrombopenia, delayed clot retraction, increased bleeding time. Reported three months after splenectomy. Cure.

CASE XLV by Reuben and Claman,¹¹⁰ 1928. Male, seven years, chronic (two years). Red blood-cells, (?); hæmoglobin, (?); bleeding time, seven minutes; platelets, 20,800 to 124,000. Transfusions before operation. After splenectomy, bleeding time, (?); platelets, (?). Purpuric spots after splenectomy; also bleeding from mucous membrane. Improvement.

CASE XLVI by Reuben and Claman,¹¹⁰ 1928. Male, eight years, chronic (four months). Red blood-cells, 3,900,000; hæmoglobin, 68 per cent.; bleeding time, three and one-half minutes; platelets, 60,000. Transfusion and "other treatment" before operation. After splenectomy, bleeding time, (?); platelets, 62,000 to 483,400. Condition excellent. Reported one year after splenectomy. Cure.

CASE XLVII by Rhame,¹²⁰ 1928. Female, seventeen years, chronic (three months). Red blood-cells, 4,272,000; hæmoglobin, 85 to 86 per cent.; bleeding time, twenty-five to eight minutes; platelets, 78,000 to 149,000. Horse serum, nasal packing, calcium chloride, transfusion before operation. After splenectomy, bleeding time, three minutes; platelets, 220,000 to 374,000. Slight bleeding from uterus checked on fourth day. Patient in excellent health. Reported three months after splenectomy. Cure.

CASE XLVIII by Schiassi,¹²⁷ 1928. Female, forty years. Other data (?). After splenectomy, no hemorrhagic symptoms. Reported four months after splenectomy. Cure.

CASE XLIX by Stewart,¹³¹ 1928. Female, three and one-half years, chronic (one year). Red blood-cells, 3,552,000 to 4,530,000; hæmoglobin, 61 to 52 per cent.; bleeding time, seven minutes; platelets, 50,000 to 22,000. Calcium lactate, ultra-violet radiation, transfusions before operation. After splenectomy, bleeding time, one and one-half minutes; platelets, 40,000 to 240,000. No recurrence. Reported three and one-half months after splenectomy. Cure.

CASE L by Stewart,¹³¹ 1928. Female, six and one-half years, chronic (sixteen months). Red blood-cells, 2,184,000 to 1,345,000; hæmoglobin, 70 to 22 per cent.; bleeding time, eight to fourteen to $3\frac{1}{2}$ minutes; platelets, 300,000 to 84,000 to 235,000 to 115,000. Transfusion, liver diet, ultra-violet before operation. After splenectomy, bleeding time, five minutes; platelets, 100,000 to 380,000 to 290,000. Reported five and one-half months after splenectomy. Cure.

CASE LI by Anschütz,² 1928. Female, forty-two years, acute (two days). Red blood-cells, 4,200,000 to 2,460,000; hæmoglobin, 85 to 45 per cent.; bleeding time, prolonged; platelets, 32,000. Transfusion before operation. After splenectomy, bleeding time, two hours; platelets, 320,000; platelets at one year are 319,000. Reported one year after splenectomy. Cure.

CASE LII by Bykowa,¹³ 1928. Male, thirty-one years, acute (four weeks). Red blood-cells, 4,800,000; hæmoglobin, 97 per cent.; bleeding time, (?); platelets, 64,200. After splenectomy, bleeding time, (?); platelets, (?). Death first post-operative day.

CASE LIII by Raine, Yates, and Davis,¹¹⁶ 1928. Female, fifteen years, chronic (one month). Red blood-cells, 1,250,000 to 3,560,000; hæmoglobin, 44 per cent.; bleeding time, (?); platelets, few—165,000. Transfusions, X-ray before operation. After splenectomy, bleeding time, (?); platelets, 87,500 to 375,000. No further bleeding. Reported six months after splenectomy. Cure.

CASE LIV by Schaack,¹²⁴ 1928. Male, twenty-seven years, chronic. Red blood-cells, 3,220,000; hæmoglobin, 82 per cent.; bleeding time, two minutes; platelets, 59,000. After

SPLENECTOMY IN PURPURA HEMORRHAGICA

splenectomy, bleeding time, (?); platelets, 274,000 to 466,000. No recurrence. Reported one year after splenectomy. Cure.

CASE LV by Schaack,¹²⁴ 1928. Female, forty years, acute (five weeks). Red blood-cells, 1,200,000; hæmoglobin, 20 per cent.; bleeding time, twenty-nine minutes; platelets, 25,000. Transfusion before operation. After splenectomy, bleeding time, (?); platelets, 100,000 to 350,000. Clinically cured. Death from pneumonia four months. Cure.

CASE LVI by Woenckhaus,¹³⁰ 1928. Male, thirty years, chronic (two years). Red blood-cells, 5,060,000; hæmoglobin, 74 per cent.; bleeding time, four to five minutes; platelets, 44,000. Serum, X-ray before operation. After splenectomy, bleeding time, (?); platelets, 156,000 to 230,000. Bleeding continued in spite of platelet-count increase, bleeding time and retractility. Reported three months after splenectomy. Improvement.

CASE LVII by Ceballos and Taubenschlag,¹⁴ 1929. Female, chronic (seven months). Red blood-cells, (?); hæmoglobin, (?); bleeding time, prolonged; platelets, 118,000. Citrated blood into left radial artery second and third days before operation. After splenectomy, bleeding time, (?); platelets, 142,000 to 164,720. No blood lost following operation. Reported six months after splenectomy. Cure.

CASE LVIII by Ceballos and Taubenschlag,¹⁵ 1929. Female, thirty-two years, chronic (five months). Red blood-cells, 1,850,000; hæmoglobin, (?); bleeding time, twenty-nine minutes; platelets, scanty. After splenectomy, bleeding time, (?); platelets, almost normal. Cure.

CASE LIX by Ceballos and Taubenschlag,¹⁵ 1929. Female, twenty-five years, chronic (four months). Red blood-cells, 4,700,000 to 2,000,000; hæmoglobin, 85 per cent.; bleeding time, (?); platelets, 50,000 to 8,000. Calcium chloride, glucose, coagulen, transfusions, bed inclined before splenectomy. After splenectomy, bleeding time, (?); platelets, 214,000 to 221,000. Patient was prepared before operation so that hæmorrhages had stopped. Cure.

CASE LX by Ceballos and Taubenschlag,¹⁵ 1929. Female, twenty-five years, chronic (two years). Red blood-cells, 3,000,000; hæmoglobin, (?); bleeding time, eight minutes; platelets, 2,346. Bicyanide of mercury before operation. After splenectomy, bleeding time, (?); platelets, 179,000 to 185,000. Cure.

CASE LXI by Frank,⁴² 1929. Male, five years, chronic (two months). Red blood-cells, 1,200,000 to 2,000,000; hæmoglobin, 60 per cent.; bleeding time, sixteen minutes; platelets, 37,000. Transfusions before operation. After splenectomy, bleeding time, (?); platelets, 210,000. No bleeding after operation. Reported five months after splenectomy. Cure.

CASE LXII by Killins,⁷⁰ 1929. Male, twenty-four years, acute. Red blood-cells, 1,200,000 to 3,400,000; hæmoglobin, 85 to 70 per cent.; bleeding time, thirty minutes; platelets, 18,000 to 4,000 to 27,000. Transfusion before operation. After splenectomy, bleeding time, normal; platelets, 400,000 to 380,000 to 165,000. Patient in perfect health. Reported three months after splenectomy. Cure.

CASE LXIII by Kogen and Genkin,⁸⁰ 1929. Male, twenty years, chronic (eight years). Red blood-cells, 5,660,000 to 4,590,000; hæmoglobin, 93 to 60 per cent.; bleeding time, ten minutes; platelets, 2,000 to 15,000 to 9,300. Calcium chloride, autohemotherapy, horse serum, neosalvarsan, mercury before operation. After splenectomy, bleeding time, 2½ minutes; platelets, 128,000 to 874,000 to 154,000. Patient well. Reported 13½ months after splenectomy. Cure.

CASE LXIV by Koster,⁸¹ 1929. Male, twelve years, six weeks' duration. Red blood-cells, 1,520,000; hæmoglobin, 20 per cent.; bleeding time, twenty minutes; platelets, 68,000. Transfusion before operation. After splenectomy, bleeding time, twelve minutes; platelets, 78,000 to 120,000. Death three months following operation from myelogenous leukæmia. Death.

CASE LXV by Koster,⁸¹ 1929. Female, seven years, chronic (one year). Red blood-cells, 3,400,000; hæmoglobin, 48 per cent.; bleeding time, forty-eight minutes; platelets, 15,700. Transfusions before operation. After splenectomy, bleeding time, twelve

minutes; platelets, 190,000. No recurrence. Reported fifteen months after splenectomy. Cure.

CASE LXVI by Koster,⁸¹ 1929. Female, twenty years, chronic (six months). Red blood-cells, 1,688,000; hæmoglobin, 23 per cent.; bleeding time, twenty-three minutes; platelets, 30,000 to 20,000. Transfusion after operation. After splenectomy, bleeding time, twenty-six minutes, platelets, 350,000. Result unknown.

CASE LXVII by Leriche and Horrenberger,⁸¹ 1929. Male, eleven and one-half years, chronic (six months). Red blood-cells, 5,100,000 to 4,610,000; hæmoglobin, 55 per cent.; bleeding time, twenty-three minutes to four hours to 14½ minutes; platelets, 86,000 to 120,000 to 169,000. Calcium chloride, transfusions, X-ray of spleen, nose, buttocks, both femurs, coagulen, anthema before operation. After splenectomy, bleeding time, twenty-seven minutes; platelets, 68,000 to 400,000 to 600,000. Patient in perfect health. Reported 8½ months after operation. Cure.

CASE LXVIII by Litchfield,⁸⁵ 1929. Female, six years, acute (two days). Red blood-cells, 2,260,000; hæmoglobin, 50 to 45 per cent.; bleeding time, fourteen minutes; platelets, 30,000 to 80,000 to 25,000. Intramuscular blood injections, transfusions before operation. After splenectomy, bleeding time, (?); platelets, 250,000 to 525,000. Cure.

CASE LXIX by Plumier-Clermont and Lambrecht,¹¹¹ 1929. Female, four and one-half years, chronic (six months). Red blood-cells, 5,000,000; hæmoglobin, 80 to 40 per cent.; bleeding time, ninety-three minutes; platelets, (?); ten cubic centimetres propeptone, 5 per cent. intramuscular weekly hemoplastin injections before operation. After splenectomy, bleeding time, 5½ to 3½ minutes; platelets, 800 to 600,000 to 615,000. Reported two months after operation. Improvement.

CASE LXX by Quénu and Stoianovitch,¹¹⁵ 1929. Immediate improvement following operation with death eleven months post-operative. Recurrence.

CASE LXXI by Schaak,¹²⁰ 1929. Female, twenty-five years, chronic (nine years). Red blood-cells, 2,300,000; hæmoglobin, 80 per cent; bleeding time, twenty-four minutes; platelets, 8,000. Röntgen-rays and other treatments before operation. After splenectomy, bleeding time, (?); platelets, 500,000. Patient well. Cure.

CASE LXXII by Abrahamsen and Meulengracht,¹ 1930. Female, twenty-four years, chronic (two years). Red blood-cells, 1,800,000 to 4,800,000; hæmoglobin, 28 to 80 per cent.; bleeding time, two hours, prolonged; platelets, 5,000 to 150,000. Transfusions before operation. After splenectomy, bleeding time, two to three minutes; platelets, 90,000 to 603,000 to 17,200. Patient has occasional bleedings. Reported twenty months after splenectomy. Improvement.

CASE LXXIII by Abrahamsen and Meulengracht,¹ 1930. Female, twenty-two years, chronic (eight years). Red blood-cells, 1,700,000; hæmoglobin, 57 to 30 per cent.; bleeding time, fifteen minutes; platelets, 1,000 to 5,000. Serum, pelvic operation before splenectomy. After splenectomy, bleeding time, five to thirty minutes; platelets, 17,000 to 57,000 to 33,000. Petechia, bleeding on slight trauma. Reported fourteen months after splenectomy. Improvement.

CASE LXXIV by Graham,⁴⁰ 1930. Female, sixteen years, acute (two days). Red blood-cells, 2,400,000 to 3,136,000; hæmoglobin, 25 to 48 to 20 to 27 per cent.; bleeding time, sixteen minutes; platelets, 31,000 to 40,000 to 136,000. Ergot, transfusions, dilatation, curettage, packing, thromboplastin before splenectomy. After splenectomy, bleeding time, 2½ to 1½ minutes; platelets, 310,000 to 208,000 to 536,000. Vaginal bleeding until fourth post-operative day. Reported five months after splenectomy. Cure.

CASE LXXV by Kerlin,⁷⁸ 1930. Female, fourteen years, chronic (eight years). Red blood-cells, 2,060,000 to 1,780,000; hæmoglobin, 60 to 40 per cent.; bleeding time, six minutes; platelets, 49,000 to 40,000. After splenectomy, bleeding time, (?); platelets, 150,000 to 148,000. Condition good. Reported four years after splenectomy. Cure.

CASE LXXVI by Kerlin,⁷⁸ 1930. Female, fifteen years, chronic (eleven years). Red blood-cells, 2,120,000 to 1,856,000; hæmoglobin, 65 to 40 per cent.; bleeding time, 10½ minutes; platelets, 140,000 to 82,000. After splenectomy, bleeding time, eight min-

SPLENECTOMY IN PURPURA HEMORRHAGICA

utes; platelets, 136,000 to 260,000. Patient in excellent health. Reported three years after splenectomy. Cure.

CASE LXXVII by Kerlin,⁷⁸ 1930. Male, ten years, chronic (seven years). Red blood-cells, 2,720,000; hæmoglobin, 75 per cent.; bleeding time, seven minutes; platelets, 48,000. Transfusions before splenectomy. After splenectomy, bleeding time, sixty minutes; platelets, (?). Death three hours after operation.

CASE LXXVIII by Kerlin,⁷⁸ 1930. Female, eighteen years, chronic (two years). Red blood-cells, 1,440,000 to 3,448,000; hæmoglobin, 20 to 45 per cent.; bleeding time, thirty to six minutes; platelets, 270,000 to 370,000 to 160,000. Eight months before operation transfusion, calcium chloride, gelatine, ultra-violet. After splenectomy, bleeding time, 3½ minutes; platelets, 240,000. Condition good. Reported two and one-half months after splenectomy. Cure.

CASE LXXIX by Marsh,⁹⁷ 1930. Male, forty-five years, acute (one week). Red blood-cells, 3,300,000 to 4,600,000; hæmoglobin, 58 per cent.; bleeding time, thirty minutes; platelets, 95,000 to 120,000. Transfusions before splenectomy. After splenectomy, bleeding time, 9 to 2½ minutes; platelets, 135,000 to 180,000. No recurrence. Cure.

CASE LXXX by Sakai,¹²² 1930. Cure.

CASE LXXXI by Washburn,¹³⁵ 1930. Female, fifteen years, chronic (seven years). Red blood-cells, 2,500,000; hæmoglobin, 25 per cent.; bleeding time, 64½ minutes; platelets, 112,000. Transfusions before operation. After splenectomy, bleeding time, ten minutes; platelets, 81,000 to 4,000. Oozing from gums and wound for four days post-operative. Profuse menstruation seventh day, controlled by transfusions. Continuous slight oozing from gums. Slight improvement. Reported four years after splenectomy. Improvement.

CASE LXXXII by Washburn,¹³⁵ 1930. Male, four and one-half years, chronic (nine months). Red blood-cells, 4,800,000; hæmoglobin, 75 per cent.; bleeding time, forty-five minutes; platelets, 28,000 to 4,000 to 13,000. Transfusions before operation. After splenectomy, bleeding time, (?); platelets, 1,175,000 to 224,000. No bleeding following operation. Reported eighteen months after splenectomy. Cure.

CASE LXXXIII by Washburn,¹³⁵ 1930. Male, four years, chronic (three months). Red blood-cells, 3,600,000; hæmoglobin, 80 per cent.; bleeding time, thirty minutes; platelets, 32,000. Transfusions before operation. After splenectomy, bleeding time, (?); platelets, 2,163,000 to 480,000. Result good. Reported five months after splenectomy. Cure.

CASE LXXXIV by Bloomfield,¹⁰ 1931. Male, thirty-four years, chronic (six months). Red blood-cells, 2,550,000; hæmoglobin, 46 per cent.; bleeding time prolonged; platelets, 9,000. Transfusions, iron, liver, calcium lactate, X-ray before operation. After splenectomy, bleeding time prolonged, normal; platelets, 44,000 to 340,000 to 20,000. No spleen found. Patient was discharged clinically well two months post-operative. Readmitted six weeks later. Death 3½ months post-operative from cerebral hæmorrhage. Death.

CASE LXXXV by deSanctis and Allen,²⁹ 1931. Male, eight years, acute (two weeks). Red blood-cells, 3,900,000 to 4,200,000 to 3,900,000; hæmoglobin, 68 to 81 to 68 per cent.; bleeding time, 3½ to 6½ minutes; platelets, 60,000 to 33,600 to 14,000. Fluids, stimulants, nasal packing, fibrinogen, thromboplastin, calcium chloride, transfusion before operation. After splenectomy, bleeding time, (?); platelets, 62,000 to 430,000 to 280,000. No recurrence. Reported 4½ years after operation. Cure.

CASE LXXXVI by deSanctis and Allen,²⁹ 1931. Male, ten years, chronic (two years). Red blood-cells, 2,400,000; hæmoglobin, 50 per cent.; bleeding time, seven minutes; platelets, 31,000. Transfusions before operation. After splenectomy, bleeding time, (?); platelets, 93,500 to 180,000. Patient well. Cure.

CASE LXXXVII by deSanctis and Allen,²⁹ 1931. Male, five and one-quarter years, chronic (several months). Red blood-cells, 550,000; hæmoglobin, 28 per cent.; bleeding time, four minutes; platelets, 21,700 to 12,000. Packing, transfusion before operation.

After splenectomy, bleeding time, $3\frac{1}{2}$ minutes; platelets, 85,900 to 302,000 to 244,700. Patient weathered lobar pneumonia, myringotomy, mastoidectomy. Repeatedly readmitted for epistaxis which gradually becomes less. Condition good. Reported two years after splenectomy. Improvement.

CASE LXXXVIII by Donovan,²⁵ 1931. Male, fifty years, acute (three days). Red blood-cells, 3,900,000; hæmoglobin, 69 per cent.; bleeding time, normal; platelets, 80,000 to 25,000. Transfusion before operation. After splenectomy, bleeding time, (?); platelets, 23,000 to 560,000 to 290,000. No post-operative bleeding. Reported thirteen days after operation. Cure.

CASE LXXXIX by Kretschmar,⁸⁵ 1931. Female, thirty-one years, chronic (seven years). Red blood-cells, (?); hæmoglobin, 15 per cent.; bleeding time, twenty minutes; platelets, 30,000. After splenectomy, bleeding time, prolonged; platelets, 500,000. Clinically cured following operation. Recurrence and cure following transfusion. Reported four years after splenectomy. Cure.

CASE XC by Le Marquand and Mills,⁹⁰ 1931. Female, fifty-two years, acute (one week). Red blood-cells, 4,300,000; hæmoglobin, 80 to 90 per cent.; bleeding time, (?); platelets, 26,000 to 120,000. Transfusion before operation. After splenectomy, bleeding time, (?); platelets, 400,000. Reported six months after splenectomy. Cure.

CASE XCI by McLean, Kreidel and Caffey,⁹¹ 1931. Acute (one month). Red blood-cells, 2,500,000; hæmoglobin, 40 per cent.; bleeding time, sixty hours; platelets, 32,000 to 56,000. Transfusion before splenectomy. After splenectomy, bleeding time, (?); platelets, (?). Ligation of aberrant gastric vein. Death.

CASE XCII by McLean, Kreidel and Caffey,⁹¹ 1931. Chronic (thirteen months). Red blood-cells, 1,900,000; hæmoglobin, 40 per cent.; bleeding time, ten minutes; platelets, 10,000 to 20,000. Transfusion before operation. After splenectomy, bleeding time, (?); platelets, (?). Bleeding from ninth to twenty-fifth days and death twenty-sixth day. Death.

CASE XCIII by McLean, Kreidel and Caffey,⁹¹ 1931. Acute (forty-eight hours). Red blood-cells, 2,800,000; hæmoglobin, 60 per cent.; bleeding time, fifteen minutes; platelets, 20,000 to 22,000. Transfusion before operation. After splenectomy, bleeding time, (?); platelets, 440,000 to 600,000. Reported two months after splenectomy. Cure.

CASE XCIV by McLean, Kreidel and Caffey,⁹¹ 1931. Chronic (two years). Bleeding time, fifteen minutes; platelets, 10,000 to 16,000. Transfusion before operation. After splenectomy, bleeding time, (?); platelets, 640,000 to 2,200,000 to 824,000. Cure permanent. Reported fourteen months after splenectomy. Cure.

CASE XCV by McLean, Kreidel and Caffey,⁹¹ 1931. Acute (two weeks). Red blood-cells, 2,700,000 hæmoglobin, 40 per cent.; bleeding time, twenty-four minutes; platelets, 32,000 to 17,000. Transfusion before operation. After splenectomy, bleeding time, (?); platelets, (?). Complete hemostasis at operation, death following. Death.

CASE XCVI by McLean, Kreidel and Caffey,⁹¹ 1931. Acute (forty-eight hours). Red blood-cells, 3,300,000; hæmoglobin, 40 per cent.; bleeding time, $6\frac{1}{2}$ hours; platelets, 36,000 to 56,000. Transfusion before operation. After splenectomy, bleeding time, (?); platelets, 328,000 to 1,176,000 to 448,000. Rapid permanent recovery. Reported four years after splenectomy. Cure.

CASE XCVII by Orloff,¹⁰⁷ 1931. Cure.

CASE XCVIII by Portis,¹¹² 1931. Male, four and one-half years, chronic (five weeks). Red blood-cells, 1,800,000 to 3,200,000 to 2,400,000; hæmoglobin, 30 to 45 to 40 per cent.; bleeding time, $8\frac{1}{2}$ minutes; platelets, 34,000 to 180,000 to 150,000. Transfusions before operation. After splenectomy, bleeding time, four minutes; platelets, 100,000 to 190,000 to 250,000. No recurrence except one severe nose-bleed five months post-operative. Reported six months after operation. Improvement.

CASE XCIX by Proctor,¹¹³ 1931. Female, forty years, chronic (twenty-five years). Red blood-cells, 1,000,000 to 4,000,000; hæmoglobin, 10 to 45 to 55 per cent.; bleeding time, eight to five to seven minutes; platelets, not counted. Transfusions, radium before

SPLENECTOMY IN PURPURA HEMORRHAGICA

operation. After splenectomy, bleeding time eighteen to $1\frac{1}{2}$ to four minutes; platelets, 350,000 to 750,000 to 330,000 to 120,000. Condition good. Reported five months after splenectomy. Cure.

CASE C by Rankin and Anderson,¹³⁷ 1931. Male, four years, chronic (one year). Red blood-cells, 3,930,000 to 4,260,000; hæmoglobin, 53 per cent.; bleeding time, sixty to forty minutes; platelets, 30,000 to 40,000, none found. After splenectomy, bleeding time, twenty-five to ten to twenty minutes; platelets, 68,000 to 24,000 to 90,000. Slight nose bleeding until thirteenth day after operation. None since. Reported one month, twenty-three days after splenectomy. Cure.

CASE CI by Smith,⁹⁹ 1931. Child, acute (five weeks). Red blood-cells, (?); hæmoglobin, 35 per cent.; bleeding time, (?); platelets, 80,000 to 20,000. Transfusions before operation. After splenectomy, bleeding time, (?); platelets, 157,000 to 300,000. No further bleeding. Reported six weeks after splenectomy. Cure.

CASE CII by Wilkie,¹³⁷ 1931. Female, fourteen years, chronic (since infancy). Red blood-cells, 4,600,000; hæmoglobin, 50 per cent.; bleeding time, fourteen minutes; platelets, 18,000. Transfusions before operation. After splenectomy, bleeding time, $4\frac{1}{2}$ minutes; platelets, 150,000 to 230,000 to 190,000. No recurrence. Reported two years after splenectomy. Cure.

CASE CIII by Zondek,¹⁴⁰ 1931. Female, thirty-two years, chronic (fifteen years). Red blood-cells, 4,000,000 to 5,000,000; hæmoglobin, 62 to 73 per cent.; bleeding time up to twenty-three minutes; platelets, 36,000 to 6,000. Transfusions before splenectomy. After splenectomy, clinically well for $4\frac{1}{2}$ years. Sudden recurrence at that time. Recurrence.

CASE CIV by Eliason and Ferguson, 1932. Male, twenty years, chronic (10 years). Red blood-cells, 3,300,000; hæmoglobin, 56 per cent.; bleeding time, $2\frac{1}{2}$ minutes; platelets, few—16,000. Thromboplastin, ceanothyn, transfusion, calcium lactate, antivenin before operation. After splenectomy, bleeding time, $2\frac{1}{2}$ minutes; platelets, 9,200 to 48,000 to 22,000. Continued bleeding for six weeks after operation. None two weeks later. Reported fifteen months after splenectomy. Cure.

CASE CV by Eliason and Ferguson, 1932. Male, seven years, chronic (three years). Red blood-cells, 4,700,000 to 4,490,000; hæmoglobin, 80 per cent.; bleeding time, $19\frac{3}{4}$ to 3 minutes; platelets, 250,000 to 160,000 to 140,000. On readmission following operation: Transfusion ultra-violet, calcium gluconate. After splenectomy, bleeding time, $2\frac{1}{2}$ to 5 to $2\frac{1}{2}$ minutes; platelets, 210,000 to 130,000 to 140,000. Readmitted seventh post-operative month because of purpuric spots and bleeding from gums. Discharged in six weeks. Reported twenty-two months after splenectomy. Cure.

CASE CVI by Eliason and Ferguson, 1932. Male, two and one-half years, acute (eight days). Red blood-cells, 4,180,000; hæmoglobin, 75 to 100 per cent.; bleeding time, one hour; platelets, 2,500 to 28,800 to 12,800. Transfusion before operation. After splenectomy, bleeding time, (?); platelets, 233,000 to 896,000 to 186,000. Excellent health. Reported seven months after operation. Cure.

CASE CVII by Eliason and Ferguson, 1932. Female, thirty-three years; chronic (three and one-half years). Red blood-cells, 2,040,000 to 1,490,000 to 2,380,000; hæmoglobin, 30 to 40 per cent.; bleeding time, prolonged; platelets, 40,000 to 320,000 to 80,000. Transfusion, antivenin, thromboplastin, calcium lactate before operation. After splenectomy, bleeding time, five to three to one minute; platelets, 210,000 to 350,000. Excellent result. Reported one year after operation. Cure.

CASE CVIII by Eliason and Ferguson, 1932. Female, twelve years, acute (two months). Red blood-cells, 1,800,000 to 2,170,000; hæmoglobin, 28 per cent.; bleeding time, thirteen minutes; platelets, 40,000—two few to count. Nasal packing, X-ray over spleen, thromboplastin, transfusions before operation. After splenectomy, bleeding time, (?); platelets, 160,000 to 125,000 to 160,000 to 70,000 to 230,000 to 100,000. Bleeding from nose third post-operative day, probably due to picking of clots. Reported two years, three months after splenectomy. Cure.

ELIASON AND FERGUSON

BIBLIOGRAPHY

- ¹ Abrahamsen, H., and Meulengracht, E.: Splenectomy in Essential Thrombopenia. *Abstr. Med. Klin.*, vol. xxvi, p. 1087, 1930.
- ² Anschütz, W.: Über Milzexstirpation bei Thrombopenien mit besonderer Berücksichtigung der akuten Fälle. *Beitr. z. klin. Chir.*, vol. cxlii, pp. 1-35, 1928.
- ³ Bachman, E. L., and Hultgren, G.: Influence de l'intervention chirurgicale en partie de l'extirpation de la rate sur la teneur du sang en thrombocyte. *Comp. rend. Soc. de Biol.*, vol. xciv, p. 942, 1926.
- ⁴ Bass, M. H., and Cohen, P.: Thrombocytopenic Purpura Hemorrhagica Successfully Treated by Splenectomy; Report of Case. *Am. Jour. Dis. Child.*, vol. xxvii, pp. 332-335, 1924.
- ⁵ Bastianelli, P.: Chronic Purpura; Case Cured by Ligation of Splenic Artery. *Atti. ital. di chir.*, vol. xxvi, pp. 96-103, 1930.
- ⁶ Bedson, S. P.: The Effect of Splenectomy on the Production of Experimental Purpura. *Lancet*, vol. ii, p. 1117, 1924.
- ⁷ Beer, E.: Essential Thrombocytopenic Purpura; Purpura Hemorrhagica and its Treatment by Splenectomy. *ANNALS OF SURGERY*, vol. lxxxiv, pp. 549-560, 1927.
- ⁸ Beer, E.: Splenectomy for Purpura Hemorrhagica. *Surg. Clin. N. Amer.*, vol. x, pp. 112-114, 1925.
- ⁹ Bloch, J.: Pathogenesis of Purpura Hemorrhagica; on Basis of Case Occurring During Course of Antisymphilitic Cure. *Med. Klin.*, vol. xxiv, pp. 296-298, 1928.
- ¹⁰ Bloomfield, A. L.: A Case of Idiopathic Thrombopenic Purpura Hemorrhagica with Microsplenia and Failure to Improve after Splenectomy. *Internat. Clin.*, vol. x, pp. 179-183, 1931.
- ¹¹ Bocage, A., and Filliol, L.: Agranulocytic Angina and Purpura Hemorrhagica During Antisymphilitic Treatment. *Bull. et mém. Soc. méd. d. hôp. de Paris*, vol. lli, pp. 1807-1811, 1929.
- ¹² Brill, N. E., and Rosenthal, N.: Treatment by Splenectomy of Essential Thrombopenia (Purpura Hemorrhagica). *Arch. Int. Med.*, vol. xxxii, pp. 939-953, 1932.
- ¹³ Bykowa, O.: Thrombopenic Purpura: Two Cases. *Virchow's Arch. f. path. Anat.*, vol. cclxviii, pp. 606-613, 1928.
- ¹⁴ Ceballos, and Taubenschlag: Splenectomy in Case of Thrombocytopenia. *Bol. de la trab. de la Soc. de cir. de Buenos Aires*, vol. xiii, p. 760, 1929.
- ¹⁵ Ceballos, and Taubenschlag: Splenectomy in Thrombocytopenic Purpura; Case Report. *Prensa med. argent.*, vol. xv, p. 1125, 1929.
- ¹⁶ Ceballos, and Taubenschlag: Purpura Hemorrhagica Cured by Splenectomy. *Semanario med.*, vol. i, p. 1320, 1928.
- ¹⁷ Clopton, M. B.: Splenectomy for Purpura Hemorrhagica. *ANNALS OF SURGERY*, vol. lxxxii, p. 413, 1925.
- ¹⁸ Cohn, I., and Lemann, I. I.: Splenectomy as a Treatment for Purpura Hemorrhagica (Thrombo-cytolytic Purpura, Kaznelson) with Report of Case and Review of Literature. *Surg., Gynec., and Obst.*, vol. xxxviii, pp. 596-604, 1924.
- ¹⁹ Cowen, S. O.: Splenectomy in Acute Essential Thrombocytopenic (Hemorrhagic) Purpura. *Med. Jour. Australia*, vol. ii, p. 279, 1925.
- ²⁰ Crawford, G. J., and Ogilvie, A. G.: Two Cases of Purpura Hemorrhagica Treated by Splenectomy. *Newcastle Med. Jour.*, vol. vii, p. 207, 1927.
- ²¹ Crousse, R.: Un cas de purpura thrombopenique traité par la ligature de l'artere splénique. *Rev. belge soc. med.*, vol. i, pp. 48-53, 1929.
- ²² Dawbarn, R. Y., Earlam, F., and Evans, W. H.: The Relation of Blood-platelets to Thrombosis after Operation and Parturition. *Jour. Path. and Bact.*, vol. xx, p. 833, 1928.
- ²³ Day, L. W.: Acute Purpura Hemorrhagica Following Administration of Sulphaphenamine, with Recovery. *U. S. Vet. Bur. Med. Bull.*, vol. vi, pp. 62-64, 1928.

SPLENECTOMY IN PURPURA HEMORRHAGICA

- ²⁴ De Leeuw: Case of Purpura Hemorrhagica Cured by Splenectomy. *J. de chir. et ann. Soc. belge de chir.*, vol. xxvi, p. 215, 1927.
- ²⁵ Denys, J.: Études sur la coagulation du sang dans un case de purpura avec diminution considerable des plaquettes. *La Cellule*, vol. iii, 1887.
- ²⁶ deSanctis, A. G., and Allen, A. W.: *Am. Jour. Dis. Child.*, vol. xli, p. 552, 1931.
- ²⁷ Dixon, M.: Purpura Treated by Injection of Human Blood. *Brit. Med. Jour.*, vol. i, p. 16, 1923.
- ²⁸ Donovan, E. J.: Splenectomy for Thrombocytopenic Purpura. *Surg. Clin. N. Amer.*, vol. xi, pp. 503-505, 1931.
- ²⁹ Duke, W. W.: The Pathogenesis of Purpura Hemorrhagica with Special Reference to the Part Played by Blood-Platelets. *Arch. Int. Med.*, vol. x, pp. 445-469, 1912.
- ³⁰ Duke, W. W.: Causes of Variation in the Platelet Count. *Arch. Int. Med.*, vol. xi, p. 100, 1913.
- ³¹ Emil-Weil, M. P., and Grégoire, R.: *Soc. Méd. Hôp de Paris*, vol. lii, p. 340, 1928.
- ³² Engel, D.: Splenectomy for Essential Thrombopenia with Special Regard to Acute Cases. *Arch. f. klin. Chir.*, vol. cxxix, pp. 563-588, 1924.
- ³³ Engel, H.: *Med. Klin.*, vol. xxiv, p. 888, 1928.
- ³⁴ Evans, W. H.: Blood Changes after Splenectomy for Purpura Hemorrhagica, with Special Reference to Platelets and Coagulation. *Jour. Path. and Bact.*, vol. xxxi, p. 815, 1928.
- ³⁵ Falconer, A. W., and McLachlan, A. R.: Two Cases of Splenectomy in Purpura Hemorrhagica. *Lancet*, vol. ii, p. 493, 1926.
- ³⁶ Farley, D. L.: Purpura Hemorrhagica (Thrombocytopenic Purpura) with Report of Case of Splenectomy. *Am. Jour. Med. Sci.*, vol. clxx, pp. 10-22, 1925.
- ³⁷ Fitz Hugh, Jr., T.: Purpura Hemorrhagica with Therapeutic Splenectomy. *Surg. Clin. N. Amer.*, Phila., vol. v, pp. 1557-1560, 1925.
- ³⁸ Fitz Hugh, Jr., T.: The Rôle of the Spleen in Health and Disease. *Atlantic Med. Jour.*, November, 1927.
- ³⁹ Fitz Hugh, Jr., T.: Recent Advances in Treatment of Purpura Hemorrhagica. *Atlantic Med. Jour.*, April, 1926.
- ⁴⁰ Flexner, M.: Idiopathic Purpura Hemorrhagica, with Report of Case Cured by Splenectomy. *Kentucky Med. Jour.*, vol. xxiii, pp. 56-61, 1925.
- ⁴¹ Frank, E.: Die essentielle thrombopenie. *Berl. klin. Wchnschr.*, vol. lii, pp. 454, 490, 961, 1915.
- ⁴² Frank, L. W.: Purpura Hemorrhagica Treated by Splenectomy; Recovery. *Kentucky Med. Jour.*, vol. xxvii, pp. 531-532, 1929.
- ⁴³ Giffin, H. Z.: Four Cases of Hemorrhagica Purpura Treated by Splenectomy. *Med. Clin. N. Amer.*, vol. viii, pp. 1153-1161, 1925.
- ⁴⁴ Giffin, H. Z.: Splenectomy. *Surg., Gynec., and Obst.*, vol. xlv, pp. 577-585, 1927.
- ⁴⁵ Giffin, H. Z.: Splenectomy in Cases of Purpura Hemorrhagica. *Minn. Med.*, vol. viii, pp. 207-214, 1925.
- ⁴⁶ Giffin, H. Z., and Holloway, J. K.: Review of Twenty-eight Cases of Purpura Hemorrhagica in Which Splenectomy Was Performed. *Am. Jour. Med. Sci.*, vol. clxx, pp. 186-204, 1925.
- ⁴⁷ Glanzmann: *Jahrb. f. Kinderheilk*, vol. lxxxviii, pp. 1 and 113, 1918.
- ⁴⁸ Gosset, M. M., Chevalier, P., and Gutmann, R. A.: *Soc. Medic. Hôp. Paris*, vol. lii, p. 364, 1928.
- ⁴⁹ Graham, H. F.: Splenectomy for Thrombocytopenic Purpura Hemorrhagica, with Case Reports. *Am. Jour. Surg.*, vol. viii, pp. 979-982, 1930.
- ⁵⁰ Gram, H. C. A.: A Case of Purpura Hemorrhagica Cured by Repeated Protein Shock. *Ztschr. f. klin. Med.*, vol. xcv, pp. 51-62, 1922.

- ⁵¹ Green, Thos. M.: Splenectomy for Thrombocytopenic Purpura Hemorrhagica. *Internat. Jour. Med. and Surg.*, vol. xli, p. 487, 1928.
- ⁵² Greenwald, H. M.: Essential Thrombocytopenia; Report of a Case in Infant Aged Four Months. *Am. Jour. Dis. Child.*, vol. xxxiii, pp. 900-904, 1927.
- ⁵³ Greenwald, H. M., and Sherman, I.: Congenital Essential Thrombocytopenia. *Am. Jour. Dis. Child.*, vol. xxxviii, pp. 1245-1251, 1929.
- ⁵⁴ Gregory, H. H. C.: Purpura Hemorrhagica Cured by Splenectomy; Case. *Brit. Jour. Child. Dis.*, vol. xxv, pp. 180-185, 1928.
- ⁵⁵ Gross, L.: Studies on the Gross and Minute Anatomy of the Spleen. *Jour. Med. Research*, vol. xxxix, p. 311, 1918.
- ⁵⁶ Harris, R. I.: Splenectomy for Purpura Hemorrhagica. *Canad. Med. Assn. Jour.*, vol. xvi, pp. 384-390, 1926.
- ⁵⁷ Harttung, H.: Splenectomy in Acute Stage of Thrombopenic Purpura. *Deutsche Ztschr. f. Chir.*, vol. clxli, p. 91, 1925.
- ⁵⁸ Hayem, C.: *Comp. Rend. Acad. d. Sci.*, vol. cxxiii, p. 899, 1896.
- ⁵⁹ Heisel, C. D.: Thrombocytopenic Purpura; Report of a Case. *Jour. Med.*, vol. ix, pp. 340-342, 1928.
- ⁶⁰ Hess, A. F.: The Blood and the Blood-vessels in Hemophilia and Other Hemorrhagic Diseases. *Arch. Int. Med.*, vol. xvii, p. 203, 1916.
- ⁶¹ Hirose, K.: Relation Between the Platelet Count of Human Blood and Its Vasoconstrictor Action after Clotting. *Arch. Int. Med.*, vol. xxi, p. 650, 1918.
- ⁶² Hitzrot, J. M.: Splenectomy in Hemorrhagic Purpura; Idiopathic Purpura, Essential Thrombopenie (Frank); Purpura Hemorrhagic Protopathique (Hayem). *ANNALS OF SURGERY*, vol. lxxviii, p. 185, 1923.
- ⁶³ Hodges, A. B.: Essential Thrombocytopenia (Purpura Hemorrhagica); Report of Case with Splenectomy. *Virginia Med. Month.*, vol. liii, pp. 582-588, 1926.
- ⁶⁴ Holloway, J. K., and Blackford, L. M.: Comparison of the Blood-platelet Count in Splenic, Arterial and Venous Blood. *Am. Jour. Med., Sci.*, vol. clxviii, p. 723, 1924.
- ⁶⁵ Inoki: *Jap. Med. World*, vol. v, p. 137, 1922.
- ⁶⁶ Jacob, F. H., and Clapperton, T.: Cure of Thrombopenic Purpura by Liver. *Brit. Med. Jour.*, vol. i, p. 823, 1930.
- ⁶⁷ Janeway, T. C., Richardson, H. B., and Park, E. A.: Experiments on the Vasoconstrictor Action of Blood Serum. *Arch. Int. Med.*, vol. xxi, p. 565, 1918.
- ⁶⁸ Jensen, J.: Purpura Hemorrhagica Following Neo-arsphenamine. *Minn. Med.*, vol. xii, pp. 689-690, 1929.
- ⁶⁹ Jones, Harold: Thrombocytopenia. *Ann. Clin. Med.*, vol. v, p. 367, 1926.
- ⁷⁰ Jones, H. C.: Case of Purpura Hemorrhagica Cured by Splenectomy. *Virginia Med. Month.*, vol. lv, pp. 245-250, 1928.
- ⁷¹ Jones, H. W.: *Med. Clin. N. Amer.*, vol. xiii, pp. 1037-1045, 1930.
- ⁷² Kaznelson, P.: Verschwinden der hämorrhagischen Diathese bei einem Falle von essentieller Thrombopenie (Frank) nach Milzexstirpation. *Splenecogene thrombolytische purpura*. *Wien klin. Wchnschr.*, vol. xxix, pp. 1451-1455, 1916.
- ⁷³ Kaznelson, P.: *Deut. Arch. f. klin. Med.*, vol. cxxviii, p. 119, 1919.
- ⁷⁴ Kaznelson, P.: *Ibid.*, vol. cxxxviii, p. 46, 1921-1922.
- ⁷⁵ Kaznelson, P.: Thrombolytische purpura. *Ztschr. f. klin. Med.*, vol. lxxxvii, pp. 133-164, 1919.
- ⁷⁶ Kennedy, R. L. J.: Diseases of Children Benefited by Splenectomy. *Jour. Am. Med. Assn.*, vol. xci, pp. 874-878, Chicago, 1928.
- ⁷⁷ Kerlin, W. S.: Treatment of Purpura Hemorrhagica by Splenectomy; with Report of Case. *New Orleans Med. and Surg. Jour.*, vol. lxxix, pp. 58-61, 1926.
- ⁷⁸ Kerlin, W. S.: Splenectomy in Thrombopenic Purpura Hemorrhagica. *Tri-State Med. Jour.*, vol. ii, pp. 338-342, 1930.

SPLENECTOMY IN PURPURA HEMORRHAGICA

- ⁷⁹ Killins, W. A.: Acute Thrombocytopenic Purpura Cured by Splenectomy. *Jour. Am. Med. Assn.*, vol. cxii, p. 1832, 1929.
- ⁸⁰ Kogen, B. E., and Genkin, I. I.: Essential Thrombopenia Cured by Splenectomy; Case. *Vrach. dielo*, vol. xii, pp. 1143-1147, 1929.
- ⁸¹ Koster, H.: Essential Thrombocytopenic Purpura; Etiology, Pathogenesis, Pathognomonic Symptoms, Diagnosis and Operative Treatment. *Med. Jour. and Rec.*, vol. cxxv, pp. 23, 97, 167, 1927.
- ⁸² Krasso, Hugo: Transfusion in Thrombocytopenic Purpura. *Wien. Arch. f. Inn. Med.*, vol. xiv, p. 377, 1927.
- ⁸³ Kretschmar, H.: Dangerous Recurrent Uterine Hæmorrhages in Essential Thrombopenia Following Splenectomy; Case. *Ztschr. f. Geburtsh. u. Gynäk.*, vol. c, pp. 368-370, 1931.
- ⁸⁴ Krumbhaar, E. B.: Function of the Spleen. *Physiol. Rev.*, vol. vi, p. 160, 1926.
- ⁸⁵ Larrabee, Ralph C.: *Am. Jour. Med. Sci.*, vol. clxviii, p. 65, 1924.
- ⁸⁶ Larrabee, Ralph C.: Transfusions in Purpura Hemorrhagica. *Jour. Am. Med. Assn.*, vol. lxxx, pp. 838-840, 1923.
- ⁸⁷ Lee, R. I., and Minot, G. R.: The Significance of Blood-platelets. *Cleveland Med. Jour.*, vol. xvi, p. 65, 1917.
- ⁸⁸ Lee, R. I., and Roberston, O. H.: Effect of Antiplatelet Serum on Blood-platelets and the Experimental Production of Purpura Hemorrhagica. *Jour. Med. Research*, n.s., vol. xxviii, p. 323, 1916.
- ⁸⁹ Lemaire, and Debaisieux: Un cas de thrombocytopenie essentielle traité par la ligature de l'artère splénique. *Bull. Belg. Acad. de Med.*, p. 149, March, 1924.
- ⁹⁰ Le Marquand, H. S., and Mills, J.: Acute Thrombopenic Purpura Cured by Splenectomy; Case. *Lancet*, vol. i, pp. 405-407, 1931.
- ⁹¹ Leriche, R., and Horrenberger, R.: Splenectomy in Child for Purpura Hemorrhagica. *Bull. et mem. Soc. nat. de chir.*, vol. lv, pp. 320-322, 1929.
- ⁹² Lesne, E., Marquezy, R. A., and Stieffel, R.: Results of Purpura Hemorrhagica Following Splenectomy; Case. *Bull. et mém. Soc. Med. d. hôp. de Par.*, vol. lii, p. 1159, 1928.
- ⁹³ Liles, R. T.: Blood-platelets in Rabbits Following Splenectomy and Transplantation of the Spleen. *Proc. Soc. Exp. Biol. and Med.*, vol. xxiii, p. 489, 1926.
- ⁹⁴ Lindsay, J. W., Rice, E. C., and Selinger, M. A.: Purpura Following Neo-arsphenamine. *South. Med. Jour.*, vol. xxiii, pp. 715-718, 1923.
- ⁹⁵ Litchfield, H. R.: Splenectomy in Acute Thrombocytopenia Purpura Hemorrhagica. *Arch. Pediat.*, vol. xlv, p. 511, 1929.
- ⁹⁶ Marin, P.: Case of Purpura Hemorrhagica with Tabulations of Clinical Tests, Semeiology and Effect of Splenectomy. *Hæmotologica*, vol. viii, pp. 47-89, 1927.
- ⁹⁷ Marsh, H. E.: Splenectomy in Acute Purpura Hemorrhagica. *ANNALS OF SURGERY*, vol. xci, pp. 313-316, 1930.
- ⁹⁸ MacCarty, W. C.: Surgically Removed Spleens. Study III. Cytology and Clinical Significance. *Proc. Staff Meet. Mayo Clinic*, vol. vii, p. 187, 1932.
- ⁹⁹ McLean, S., Kreidel, K., and Caffey, J.: Hemorrhagic Thrombocytopenia in Childhood. *Jour. Am. Med. Assn.*, vol. xcvi, p. 387, 1932.
- ¹⁰⁰ Merklen, and Leriche: Un cas d'hémogénie guéri par splénectomie. *Soc. med. de hôp. de Par.*, vol. lii, p. 1614, 1928.
- ¹⁰¹ Mills, E. S.: Recent Advances in Hematology; Value of Splenectomy in Purpura Hemorrhagica. *Canad. Med. Assn. Jour.*, vol. xvi, pp. 957-958, 1926.
- ¹⁰² Minot, G. R.: *Trans. Assoc. Amer. Physiol.*, p. 312, 1923.
- ¹⁰³ Moffatt, C. F.: *Canad. Med. Assn. Jour.*, vol. x, p. 452, 1920.
- ¹⁰⁴ Muller, Geo. P.: The Indications for Splenectomy. *Atlantic Med. Jour.*, November, 1927.

- ¹⁰⁵ Myers, B., Maingot, R., and Gordon, A. K.: Splenectomy for Essential Thrombocytopenic Purpura Hemorrhagica. *Proc. Roy. Soc. Med. (Clin. Sect.)*, vol. xix, pp. 31-34; 37-40, 1926.
- ¹⁰⁶ Narog, F.: Contribution a la pathogenie des diathese hemorrhagiques essentielles. Un cas de purpura thrombolytica haemolyticagueri par la splenectomie. *Arch. d'ophth.*, vol. xlv, pp. 429-441, 1927.
- ¹⁰⁷ Orloff, I. I.: Essential Thrombopenia Successfully Treated by Splenectomy. *Med. nusl. uzbek. i turk.*, vol. v, pp. 1-7, 1931.
- ¹⁰⁸ Paiseau, G., and Alcheck: Peptone Shock Treatment in Hemorrhagica Purpura. *Bull. et mém. Soc. Méd. d. hôp. de Par.*, vol. xlvii, pp. 258-263, 1923.
- ¹⁰⁹ Pancoast, H. K., Pendergrass, E. P., and Fitz Hugh, Jr., T.: The Present Status of the Röntgen Treatment of Purpura Hemorrhagica by Irradiation of the Spleen. *Am. Jour. Roent. and Rad. Therap.*, vol. xiii, pp. 558-567, 1925.
- ¹¹⁰ Pinkerton, C. C.: Splenectomy as Curative Measure in Essential Thrombocytopenic Purpura. *Ohio Med. Jour.*, vol. xxiv, pp. 788-791, 1928.
- ¹¹¹ Plumier-Clermont, L., and Lambrecht: Case of Purpura Hemorrhagica Cured by Splenectomy. *Ann. Soc. med.-chir. de Liege*, vol. lxii, pp. 15-21, May, 1929.
- ¹¹² Portis, B.: Thrombocytopenic Purpura Treated by Splenectomy. *Surg. Clin. N. Amer.*, vol. xi, pp. 153-156, 1931.
- ¹¹³ Proctor, R.: Chronic Thrombocytopenic Purpura Hemorrhagica Cured by Splenectomy. *Jour. Am. Med. Assn.*, vol. xcvi, pp. 109-110, 1931.
- ¹¹⁴ Quénu, J.: Results of Splenectomy for Purpura Hemorrhagica. *Rev. de chir.*, vol. lxvii, pp. 24-39, 1929.
- ¹¹⁵ Quénu, J., and Stoïanovitch, S. M.: Chronic Recurrent Purpura Treated by Splenectomy with Immediate Improvement, Followed by Death in Eleven Months from Recurrent Hemorrhages. *Bull. et mem. Soc. Nat. de chir.*, vol. lv, pp. 111-121, 1929.
- ¹¹⁶ Raine, F., Yates, J. L., and Davis, C. H.: Thrombocytopenic Purpura; Report of Patient's Progress. *Wisconsin Med. Jour.*, vol. xxvii, pp. 215-218, 1928.
- ¹¹⁷ Rankin, F. W., and Anderson, R. S.: Splenectomy for Hemorrhagica Purpura of Children. *ANNALS OF SURGERY*, vol. xciii, pp. 749-755, 1931.
- ¹¹⁸ Reilingh, W.: Case of Splenectomy in Essential Thrombopenia. *Nederl. Tijdschr. v. Geneesk.*, vol. i, pp. 441-445, 1926.
- ¹¹⁹ Reuben, M. S., and Claman, L.: Splenectomy in Acute Thrombocytopenic Purpura Hemorrhagica. *Arch. Pediat.*, vol. xlv, pp. 84-97, 1928.
- ¹²⁰ Rhame, J. S.: Purpura Hemorrhagica Cured by Splenectomy. *Jour. South Carolina Med. Assn.*, vol. xxiv, p. 247, 1928.
- ¹²¹ Rockwood, R., and Sheard, C.: Instantaneous Photomicrography of the Blood-platelets. *Arch. of Pathol.*, vol. i, p. 742, 1926.
- ¹²² Sakai, Y.: Case of Purpura Hemorrhagica Cured by Splenectomy. *Okayama-Igakkai-Zasshi*, vol. xlii, p. 137, 1930.
- ¹²³ Schaack, W.: Treatment of Purpura Hemorrhagica by Excision of Spleen. *Deutsche Ztschr. f. Chir.*, vols. cciii-cciv, pp. 62-70, 1927.
- ¹²⁴ Schaack, W.: Splenectomy in Essential Thrombopenia; Clinical Observations and Experimental Studies. *Arch. f. klin. Chir.*, vol. clii, pp. 649-658, 1928.
- ¹²⁵ Schaak, V. A.: Removal of the Spleen in Thrombopenia Essentialis. *Vestnik Khir.*, vol. ix, No. 25, pp. 50-60, 1927.
- ¹²⁶ Schaak, V. A.: The Method of Splenectomy in Essential Thrombopenia. *Vestnik Khir.*, vol. xviii, No. 53, pp. 52-55, 1929.
- ¹²⁷ Schiassi, F.: Two Cases of Purpura Hemorrhagica Cured by Splenectomy. *Arch. di pat. e clin. med.*, vol. vii, pp. 73-95, 1928.
- ¹²⁸ Spence, A. W.: Results of Splenectomy for Purpura Hemorrhagica. *Brit. Jour. Surg.*, vol. xv, pp. 466-499, 1928.

SPLENECTOMY IN PURPURA HEMORRHAGICA

- ¹²⁹ Steiner, P. E., and Gunn, F. D.: Effect of Splenectomy and of Other Surgical Procedures upon Circulating Blood-platelets (Rabbits). *Proc. Soc. for Exp. Biol. and Med.*, vol. xxviii, p. 1088, June, 1931.
- ¹³⁰ Steiner, P. E., and Gunn, F. D.: The Response of Blood-platelets to External Stimuli; Ultra-violet Light, Iodine, Coal Tar. *Arch. of Path.*, vol. xi, pp. 241-254, 1931.
- ¹³¹ Stewart, W. B.: Splenectomy for Purpura Hemorrhagica in Childhood. *Jour. Med. Soc. New Jersey*, vol. xxvi, pp. 116-124, 1929.
- ¹³² Sutherland, G. A., and Williamson, B.: Treatment of Purpura Hemorrhagica by Splenectomy. *Lancet*, vol. i, pp. 323-327, 1925.
- ¹³³ Thiel, O.: Purpura Hemorrhagica from Therapeutic Use of Myosalvarsan. *Ztsch. f. klin. Med.*, vol. cix, pp. 279-284, 1928.
- ¹³⁴ Vincent, B.: Splenectomy in Thrombopenic Purpura Hemorrhagica. *Boston Med. and Surg. Jour.*, vol. clxiii, pp. 191-200, 1925.
- ¹³⁵ Washburn, A. H.: Splenectomy in Thrombopenic Purpura; Three Cases. *Jour. Am. Med. Assn.*, vol. xciv, pp. 313-317, 1930.
- ¹³⁶ Whipple, A. O.: Splenectomy as Therapeutic Measure in Thrombocytopenic Purpura Hemorrhagica. *Surg., Gynec., and obst.*, vol. xlii, pp. 329-341, 1926.
- ¹³⁷ Wilkie, D. P. W.: Splenectomy: Its Indications and Technique. *Am. Jour. Surg.*, vol. xiv, p. 1, 1931.
- ¹³⁸ Williamson, Bruce: Recent Advances in the Diagnosis and Treatment of Purpura Hemorrhagica. *Arch. Dis. Child.*, vol. i, pp. 39-49, 1926.
- ¹³⁹ Woenckhaus, E.: Extirpation of Spleen in Essential Thrombopenia; Case. *Ztschr. f. klin. Med.*, vol. cix, pp. 279-284, 1928.
- ¹⁴⁰ Zondek, B.: Dangerous Uterine Hemorrhage Cured by Splenectomy; Recurrence after Four and One-half Years; Case. *Zentralbl. f. Gynäk.*, vol. lv, pp. 1791-1794, 1931.
- ¹⁴¹ von Goidsenhoven: Essential Thrombopenia and Its Treatment by Ligation of the Splenic Artery. *Ann. Soc. Sci. Brux.*, p. 47, July, 1927.

THE TUMORS OF THE STERNUM

REPORT OF REMOVAL OF A LARGE MEDIASTINAL STERNAL CHONDROMYXOMA

By GEORGE J. HEUER, M.D.

OF CINCINNATI, OHIO

THE intrathoracic chondromas and chondromyxomas include a group of tumors arising from the costal cartilages, sternum, costovertebral articulations and spine (intervertebral discs) which encroach upon the intrathoracic space and mediastinum. Pathologically, they comprise two kinds of tumors; those which are solid and made up of cartilage (chondromas), and those which are partly solid (cartilage) and partly cystic—the cystic portion consisting of a ropy, sticky, clear or opalescent fluid or a gelatinous material. Whether these represent two different varieties of cartilaginous tumors or whether the cystic variety called chondromyxoma represents a degeneration form of chondroma is a question I leave for the present outside of this discussion. From the viewpoint of surgery they have the characteristics in common that they are circumscribed, encapsulated tumors which in their growth crowd the thoracic or mediastinal structures to one side, do not as a rule invade them, and rarely become firmly adherent to them. Were it not, then, for the size which they have frequently attained, when patients harboring them present themselves for diagnosis and treatment, their surgical removal should be comparatively simple.

These tumors are not common. In a series of 213 cases of tumor of the ribs and sternum (the collected cases of Parham, Lund and Hedblom) chondromas, chiefly of the costal cartilages, occurred in forty. Of 205 tumors of the ribs and sternum which I personally studied several years ago, 164 (80 per cent.) were tumors of the ribs, thirty-two (15 per cent.) were tumors of the sternum and the remainder (five) scattered. Of the thirty-two sternal tumors studied, twenty were sarcomas; two, chondromas; three, fibromas; two, carcinomas, and one each a gumma and chronic inflammation. It is apparent from these studies that the chondromas and chondromyxomas of the costal cartilages are infrequent and those of the spine and the costovertebral articulations quite rare tumors; suppositions which are borne out by the fact that in a growing series of intrathoracic new growths, I have seen but two examples.

The first is a large intrathoracic chondromyxoma occupying the upper half of the right thoracic cavity and arising presumably from the costovertebral articulations of the fourth and fifth ribs. The case was seen and operated upon in November, 1920, and was reported in the *ANNALS OF SURGERY* in 1924. The second, seen and operated upon within the past year, is a large mediastinal chondromyxoma arising from the sternum and forms the basis of this report. The protocol follows:

THE TUMORS OF THE STERNUM

Miss A. Z., aged fifty-six years, was admitted to the Cincinnati General Hospital June 1, 1931, complaining of pain in the chest and shortness of breath. Her family history is unimportant. She, herself, was well until 1904, when she had what was said to be an attack of pleurisy. Shortly thereafter she noticed a small, hard tumor mass upon the sternum just to the right of the midsternal line. This slowly grew in size and with its growth there occurred, periodically, paroxysms of sharp pain in the right thorax, sometimes extending into the left thorax beneath the left breast. These symptoms continued without much change for fourteen or fifteen years when the tumor rather suddenly began to grow more rapidly in size. She consulted a surgeon (she was then living in Switzerland) who in 1920 removed the tumor and told her it was a harmless growth of cartilage. She was relieved of her pain and apparently was well. On October 28, 1924, she consulted me for an attack of acute upper abdominal pain and a diagnosis of acute cholecystitis was made. I operated upon her at once and removed an acutely inflamed, greatly distended gall-bladder associated with a stone impacted in the cystic duct. She made an uneventful recovery. At this time I learned of the previous operation for chondroma of the sternum and made a careful examination of her chest. There was a curved scar over the lower portion of the sternum about which the sternum was normal on inspection and palpation. The thorax was negative on examination. There was absolutely no external evidence of recurrence at this time and she was quite free from pain. Unfortunately, however, an X-ray of her thorax was not made.

The patient was again well until November of 1929, when she had a recurrence of the "pleurisy" and soon after noticed a recurrence of the tumor. The paroxysms of pain previously complained of became increasingly severe and more frequent. By 1930 the pain was more or less constant with now and then an agonizing, hot, burning pain through her chest. Drugs at first relieved the pain but more recently such huge doses became necessary that she has been in a somnolent condition a good part of the time. X-rays of her chest were made in 1929, 1930, and 1931 and all show a large mediastinal shadow; but a diagnosis was not positively made. Some time before coming to the Cincinnati General Hospital she had some dyspnoea, especially on exertion, and noted some fullness of the vessels of her neck. On her admission to the hospital she was only eight pounds under her previous best weight.

Examination.—The patient's general physical condition is good. There is no dyspnoea or cyanosis while lying quietly in bed. Her color is good. There is a slight ptosis of the left upper lid but no other evidences of involvement of the sympathetic. The patient is alert and coöperative.

The general physical examination is negative excepting for the thorax. Over the upper part of the thorax anteriorly there is a slight but definite enlargement of the superficial veins, the size of which is accentuated by straining and coughing. Projecting from the anterior surface of the sternum is a visible swelling which is flat and which shades imperceptibly into the surrounding bone. It has no definite outlines; approximately it is 6 by 6.5 centimetres in diameter. The swelling is hard and elastic and lies under the scar of the operation performed in 1920. Palpation of it and percussion about it is painful. Expansion of the thorax is good. Percussion and auscultation over the lungs are quite negative. There is definite dullness behind and to either side of the sternum. The cardiac dullness evidently is displaced to the left. The heart sounds are clear.

The blood failed to show anything remarkable. There is a slight anæmia. The urine was negative on several examinations. The Wassermann reaction is negative.

The six series of X-ray films made between December 2, 1929, and June 1, 1931, all show a large mediastinal shadow and displacement of the heart to the left (Fig. 1). Careful comparison of the various films fails to show any appreciable increase in the size of the shadow. In the plates from 1930 on, there appears a small circular shadow in the left costophrenic angle (Fig. 1 M) which was thought to be a possible metastasis

in the lung (This has since been closely followed and films made May 1, 1932, show that it has increased in size. When first observed it measured on the film 1.5 centimetres in diameter; at the present time, two years later, it measures 2.5 centimetres to 3 centimetres in diameter.)

A diagnosis of mediastinal chondroma arising from the sternum was made. It seemed doubtful in view of the large size of the tumor that surgical removal could be successful; yet because of the severity of the pain, an exploration with an attempt at removal seemed justified. The patient readily agreed to such an operation.

Operation was performed June 2, 1931, under positive-pressure gas-oxygen-ether anæsthesia. Since the larger part of the tumor lay on the right side, a curved incision forming a flap was made about three inches from the midsternal line. The skin and subcutaneous tissues were reflected to the right, exposing the pectoral muscle. This was dissected off from the sternum and ribs so as to preserve all muscle possible with



FIG. 1.—X-ray taken before operation. The large mediastinal tumor has crowded the heart to the left. The supposed metastasis in the lung is indicated by "M."

the exception of that portion of it which overlay the external tumor. The muscle being reflected from the costal cartilages, these were freed and divided with a rongeur well to the right of the border of the tumor. The cartilages of the seventh, sixth, fifth, fourth and third ribs were thus divided. An attempt was then made to strip the underlying pleura, but it at once became evident that this was fused with the tumor mass. The pleura therefore was deliberately opened throughout the extent of the wound. The anæsthetist was able to distend the right lung at will so that we proceeded without anxiety.

The right border of the mediastinal tumor was immediately brought into view. The tumor was so large that we were doubtful whether it was wise to attempt its removal. The lower border of the tumor extended downward to the point of attachment of the diaphragm to the xiphoid. Above there was a prolongation of the tumor which extended up to the suprasternal notch. However, it became apparent almost immediately

THE TUMORS OF THE STERNUM

that there were no firm adhesions between the tumor and the surrounding structures, and I proceeded gingerly to free the right lateral border from the adjacent lung. This proved not to be difficult, and in a very short time I had exposed the right side of the tumor throughout its entire length. I continued freeing the tumor upwards and downwards until I had quite encircled both its lower and upper poles. I inserted my hand deeply into the chest and found that I could surround the posterior or dorsal border of the tumor which extended quite to the spine. Very carefully, I swept my hand around the tumor until I came to the left lateral border of the growth, and here I found it lying adjacent to the heart and great vessels. Very fortunately, here also there were no dense adhesions between the tumor and the surrounding structures, and in a very short time I had swept my hand completely around the tumor so that my hand came in contact with the chest wall beyond its left lateral border.

Having gone this far I next continued the resection of the sternum around to the left. This procedure was performed in the same way as on the right side; that is, the pectoral muscle was stripped from the chest wall and the costal cartilages exposed. I then cut across each costal cartilage with a rongeur so that eventually I had surrounded the entire tumor, giving it a wide berth in all directions. The tumor was then removed completely and with the lower two-thirds of the sternum.

Throughout the procedure there was no hæmorrhage whatsoever. There was left the most astonishing opening into the chest I have ever seen. Both lungs lay exposed in the wound, as did the heart and great vessels. Fortunately, although the right pleura was opened widely, the left was not, and the anæsthetist had the situation in perfect control. The right pleural cavity was dried by suction and there remained the closure of the wound. The pectoral muscle on either side was brought to the mid-line and sutured with interrupted sutures of silk. In this procedure the right breast was dislocated mesially and helped very much to fill the cavity. Another layer of sutures was placed in the subcutaneous tissues and the skin was then closed with interrupted fine silk. Just at the end of the procedure, a trochar was introduced into the right thorax and the air aspirated.

At the completion of the closure the patient was in very good condition. There was no cyanosis. The pulse was under 100. What seemed to be a disturbing thing was the remarkable suction inward of the wound on inspiration. This, it seemed to me, might markedly interfere with respiration, defeating the inspiratory act. I therefore made a breast plate of rigid cardboard and fastened it air-tightly over the front of the chest with broad strips of adhesive. Whether this really had anything to do with maintaining proper respiration is doubtful. The respiration remained at all times good and was equally good two days later when the cardboard was removed.

Post-operative notes.—One cannot imagine a smoother post-operative course. The pain immediately disappeared and the patient even in the first days of convalescence was far more comfortable than before the operation. There was at no time any dyspnoea and her color was always good. The wound healed *per primam*. Repeated X-rays taken with a movable unit failed to show any accumulation of fluid in either half of the thorax. There was, for the first week after operation, a partial right pneumothorax. The air, however, was promptly absorbed and the right lung completely expanded by the tenth post-operative day. The right diaphragm in the post-operative X-rays occupied an elevated position and as soon as the patient was up and about fluoroscopical examination showed that the right diaphragm was immobile and in high position. Fluoroscopical examination prior to operation showed a mobile diaphragm. The injury to the phrenic nerve evidently occurred during the removal of the tumor. The patient was discharged from the hospital June 23, 1931, three weeks after operation.

Gross pathology.—During the course of the removal of the tumor it was ruptured and there escaped a large quantity of sticky, gelatinous fluid. The weight of the tumor, which on removal was 557 grams, was therefore probably twice this amount. Partially collapsed, the tumor measured 14 centimetres long by 10 centimetres wide by 10 centi-



FIG. 2.

FIG. 2.—Ventral aspect of the tumor after removal. The divided ends of the costal cartilages attached to the lower two-thirds of the sternum in the foreground. The tumor as noted extended from the xiphoid to the suprasternal notch.



FIG. 3.

FIG. 3.—Section of the tumor showing its solid and cystic portions.

THE TUMORS OF THE STERNUM

metres thick. Measured along the curve of the tumor it measured 21 centimetres long, 10 centimetres wide and 10 centimetres thick. The tumor is intimately associated with the sternum and has risen from this structure. It has perforated the bone so that it presented as a raised elevation on the external surface of the body. This external portion of the tumor is firmly elastic on palpation. The mediastinal portion of the tumor is perfectly encapsulated, the capsule being a structure which varies in thickness up to two to three millimetres. The tumor has undergone extensive degeneration, the degenerated material consisting of a sticky gelatinous fluid. The solid portion of the tumor consists of cartilage intermeshed with masses of calcification.

Gross Pathological Diagnosis.—Chondromyxoma. (See Figs. 2, 3 and 4.) *Microscopical Diagnosis.*—The sections made consist of a completely encapsulated mass of tissue made up of well-formed cartilage surrounding areas of myxomatous degeneration.

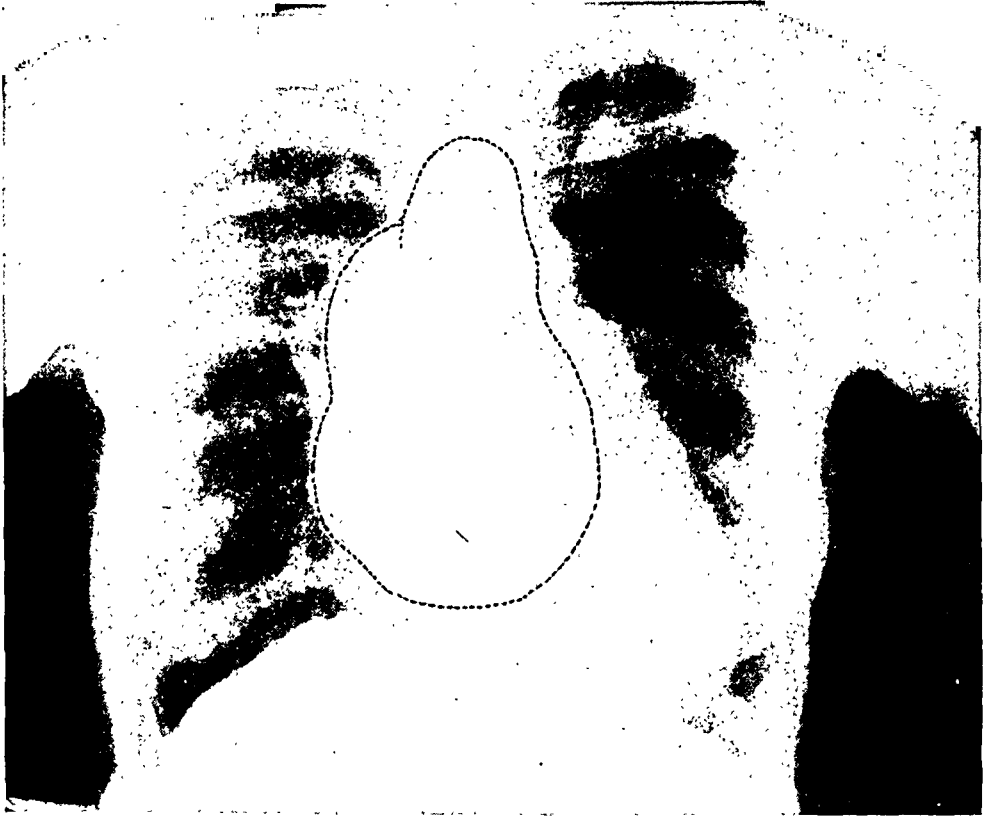


FIG. 4.—The outline of the tumor has been dotted upon the X-ray film to show the extent and relations of the tumor.

Hæmorrhage is also seen here and there throughout the section. The *microscopical diagnosis* is chondromyxoma benign.

Follow-up Notes.—The patient returned for observation July 1, 1931, at which time following note was made:

It is now four weeks since the operation. The wound is completely healed. The patient generally looks well and feels well.

At the site of the operation there is a depression due to the loss of the sternum. With each inspiration this depression sinks slightly, and on expiration again moves forward. The right breast in part fills the defect. Respiration is quiet. The patient's color is good. There is no dyspnœa. Functionally the loss of the lower two-thirds of the sternum seems a very minor matter. Under the fluoroscope the chest moves well, with the exception of the right diaphragm. This occupies a high position and is immobile. There seems no doubt that the right phrenic nerve was traumatized during the removal of the tumor.

Palpating the divided ends of the ribs, the defect in the anterior thoracic wall is

roughly circular in outline and measures 11 centimetres in vertical and $10\frac{1}{2}$ centimetres in transverse diameters. Most of the defect lies to the right of the mid-line. It is



FIG. 5.

FIG. 6.

FIG. 5.—Antero-posterior X-ray taken ten months after operation. The supposed metastasis in the left costophrenic angle (M) has definitely increased in size. Shadows along the right mediastinum and in the right lung held suggest metastases.

FIG. 6.—Lateral X-ray taken ten months after operation.

apparent on examination that the sternum has not been entirely removed but that the upper segment remains. All of the lower part of the sternum has been removed down to the xiphoid. At the time of the operation the costal cartilages of all the lower ribs

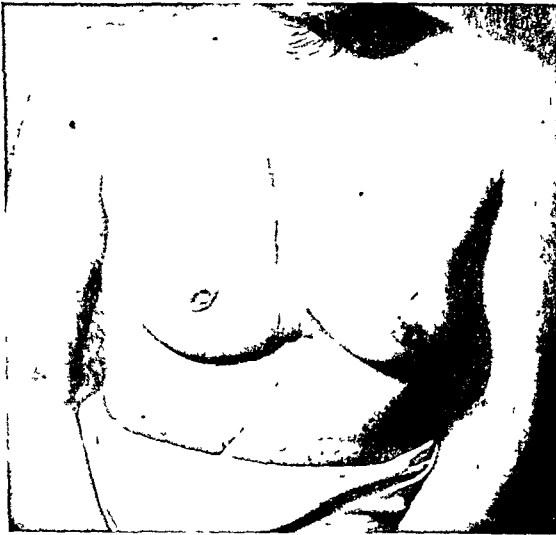


FIG. 7.



FIG. 8.

FIG. 7.—Photograph taken ten months after operation showing operative scar.

FIG. 8.—Lateral photograph taken ten months after operation to show the depression of the anterior thorax.

were divided. Since that time they have come together so as to diminish the epigastric angle.

X-rays of the chest were taken today. The vital capacity this morning was 1,200 cubic centimetres, which is rather low. Weight, 106 pounds.

THE TUMORS OF THE STERNUM

She was seen again October 1, 1931, and the following note made:

Since the last note the patient has gained six pounds. Her color is very much better. She has been quite vigorous—driving her car, *etc.*

Examination of the chest shows the wound perfectly healed with a very good scar. The defect in the anterior thorax has not diminished. It now measures eleven centimetres vertically by eleven centimetres in its greatest transverse diameter. On respiration the region of the defect moves in and out as would be expected. With the patient lying quietly there is very little cardiac pulsation although it can be observed.

On coughing there is considerable bulging in the region of the defect. Respiration is perfectly quiet. There is no shortness of breath on exertion.

X-ray of the thorax taken October 1, 1931, shows the chest perfectly clear. The heart has moved back towards the mid-line although it still is displaced considerably toward the left. The right half of the diaphragm (paralyzed as described in our previous note) does not in this X-ray occupy a high position. Fluoroscopical examination shows that the right diaphragm moves actively and within normal excursions. The paralysis of the right diaphragm noted June 29, 1931, has in the meantime entirely disappeared.

The patient was seen again on April 1, 1932. She had gained twelve pounds since operation. She seemed perfectly well and is leading an active normal life. The X-rays of the thorax show that the presumed metastasis in the lung has increased in size (Figs. 5 and 6 M), but otherwise are negative. Photographs of the patient (Figs. 7 and 8) show the operative scar and the depression of the anterior thorax.

Later reports from the patient were not so encouraging. In May, 1932, she began to complain of "sciatica" in the left leg. The pain radiated along the course of the sciatic nerve and eventually became so severe that she became practically bedridden. Knowing the propensity of these tumors to metastasize she was repeatedly examined and her spine and pelvis X-rayed to determine the presence of metastases. None was found. Later there appeared a nodule at the upper portion of the operative defect to the right of the mid-line which impressed us as either a recurrence in the sternum or a recurrence in the mediastinum presenting at the margin of the bony defect. A similar nodule appeared in the region of the xiphoid at the lower margin of the defect. June 11, 1932, I saw the patient and agreed with Dr. B. N. Carter, who then had the patient in charge, that these nodules, which seemed perfectly circumscribed, should be explored and if possible removed. The operation was performed by Doctor Carter, June 15, 1932. He writes me under date of June 20, 1932, as follows:

"Five days ago I operated on Miss Z. I attacked the upper lump first, making a long skin incision over it, and freed it down to the costal cartilage. I resected the costal cartilage and opened the pleura for it was obvious that I would have to resect a piece of pleura in order to remove the tumor without getting into it. It was a little difficult to say in which pleural cavity I was but I believe I was in the right. Upon introducing my finger I could detect numerous large metastases about the size of golf balls apparently in the mediastinum. The tumor which had appeared on the outside was a continuation of one of these which had grown through the intercostal space. I removed the tumor but I had to cut through portions of it. This I did more for the mental effect upon the patient than with any idea of a cure. I carried through a similar procedure on the lowermost recurrence and found the same state of affairs there. I am afraid she has no chance."

Comments.—The case illustrates the ease with which even very large tumors of this nature may be removed. The sad end-result raises the question as to the origin of the metastases. Previous to the original operation our X-ray studies showed only one possible metastasis, *i.e.*, that in the lower lobe of the left lung. (Fig. 1 M.) This was not examined at the time of

the original operation because the left pleural cavity was not opened. But the mediastinum, the right pleural cavity and the right lung were thoroughly examined at operation and no evidence of metastases found. Is it possible that the numerous nodules in the mediastinum found by Doctor Carter represent implantations due to the rupture of the original tumor during its removal?

DISCUSSION OF TUMORS OF THE STERNUM

Zinninger (*ANNALS OF SURGERY*, vol. xcii. p. 1043, 1930) collected the cases of tumors of the thoracic wall between the time of my studies (1927) and 1930. He found twenty additional cases reported and to this number added eight from the records of the Peiping Medical School. He brings the total number of tumors of the thoracic wall reported in the literature up to 266. I have again gone over the literature with special reference to tumors of the sternum, and, including the case I have just recorded, find thirty-eight cases which are reported and described as tumors of the sternum. Fifteen of them are reported between 1873 and 1890; six between 1890 and 1900; and seventeen between 1900 and the present time. The descriptions of the earlier cases are often faulty and one is left in doubt whether the tumor originated in the sternum or primarily in the clavicle or ribs. As to their point of origin in the sternum, seven are said to have arisen in the gladiolus, nine in the manubrium, two in the gladiolus and manubrium, and one in the xiphoid. The remaining twenty are simply described as arising from the sternum. One of these almost certainly had its origin in the inner end of the clavicle. The pathological descriptions also are often faulty. Thirteen cases are simply designated as sarcomas; seven additional cases are described as myxosarcoma, one; melanosarcoma, one; fibro-myxosarcoma, one; round-cell sarcoma, two; and spindle-cell sarcoma, two. The remaining eighteen cases form pathologically a heterogeneous group: gumma, one; "fibroid" tumor, three; chondroma (including my case), three; carcinoma, two; hypernephroma, two; "malignant thyroid tumor," one; vascular tumor or aneurism, one; and chronic inflammation, one. In one case (Weinlechner) two apparently different tumors of the sternum occurred in the same patient; one a primary chondroma of fifty years' duration, the other a "colloid sarcoma" of three years' duration. In three cases the pathological diagnosis of the tumor is not stated.

Of the thirty-eight tumors of the sternum, therefore, nineteen, or 50 per cent., are primary sarcomas; and to this number probably should be added the three so-called "fibroid tumors." Three or possibly four (12 per cent.) are primary cartilaginous tumors (chondroma; enchondroma; chondromyxoma), one is a gumma, and one is a chronic inflammatory lesion. The remaining seven tumors (18 per cent.) in which a diagnosis is stated are secondary, metastatic lesions. Of these, three were pulsating tumors and the primary diagnosis was aneurism. In one, the diagnosis of hypernephroma was con-

THE TUMORS OF THE STERNUM

firmed by biopsy, in a second, the diagnosis of hypernephroma was established by necropsy; in the third, a positive diagnosis was not established.

It will be seen from this summary that the primary cartilaginous tumors of the sternum are rare, the case just described by me being the third or possibly the fourth to be reported.*

Of the thirty-eight cases, thirty-four were subjected to a more or less radical operation, two to a biopsy for diagnostic purposes, and one to radium treatment. One was not treated.

Of the thirty-four cases subjected to a more or less radical operation, eight died within fifteen days of the operation, and twenty-three recovered. In three cases neither the immediate nor late result of the operation is given. Of the twenty-three cases which recovered, three failed to show evidence of recurrence from one to two years and were living at the time of the report. Nine cases presented recurrences from one month to two years after operation from which six died. In ten cases the end-result is not given. The single case which is known from the reports in the literature to have survived beyond a two-year period is one, not of tumor, but of chronic inflammation. Of the three cases of enchondroma subjected to operation, one died five days after operation from pyæmia, and two showed recurrences or metastases within a year after operation.

A brief summary of the cases of tumor of the sternum thus far reported is appended.

CASE I.—Holden: Brit. Med. Jour., vol. xi, p. 358, 1878. A woman, aged fifty-two, with a sarcoma involving the gladiolus. At operation the tumor was partially removed. Details of the operation are lacking. Neither the immediate nor the late results of the operation are given.

CASE II.—König: Centralb. f. Chir., No. 42, 1882. A woman, aged thirty-six, with a sarcoma of the sternum. At operation the gladiolus, a part of the manubrium, the second to the eighth ribs on the left and the ends of the cartilages on the right were resected. Both internal mammary arteries were ligated. The pericardium was opened. Both pleuræ were opened (openings probably small) causing slight respiratory difficulty and tachycardia. The management of the bilateral pneumothorax is not stated. The patient recovered but died two years later from recurrences in the lungs. Paget commenting upon this case states that the patient died one year after operation from rheumatic fever.

CASE III.—Küster: Berlin klin. Wchnschr., p. 127, 1882. A man, aged thirty, with a tumor, later diagnosed a gumma, of the sternum. At operation the right half of the gladiolus and the third and fourth ribs were resected. One pleural cavity was slightly opened. Whether or not respiratory or cardiac disturbances followed is not stated. The patient recovered from the operation. The late result is not given.

CASE IV.—Pfeiffer: Beitr. z. Kennt. d. Sternal Tumoren, Halle, 1884. A man, aged forty-five, with a sarcoma of the gladiolus. At operation, the gladiolus and the second, third and fourth ribs right and left were resected. The right pleura was opened and probably also the pericardium. The patient developed an acute pericarditis and

* The fourth case I have in mind is that of Gangolph et Tixier in Lyon Chir., vol. ii, p. 112, 1909-1910, under the title of "Enorme Enchondrome de la fourchette sternale. Resection de la moitié supérieure du Sternum, etc." Unfortunately, this reference at the moment is not available.

the original operation because the left pleural cavity was not opened. But the mediastinum, the right pleural cavity and the right lung were thoroughly examined at operation and no evidence of metastases found. Is it possible that the numerous nodules in the mediastinum found by Doctor Carter represent implantations due to the rupture of the original tumor during its removal?

DISCUSSION OF TUMORS OF THE STERNUM

Zinninger (*ANNALS OF SURGERY*, vol. xcii, p. 1043, 1930) collected the cases of tumors of the thoracic wall between the time of my studies (1927) and 1930. He found twenty additional cases reported and to this number added eight from the records of the Peiping Medical School. He brings the total number of tumors of the thoracic wall reported in the literature up to 266. I have again gone over the literature with special reference to tumors of the sternum, and, including the case I have just recorded, find thirty-eight cases which are reported and described as tumors of the sternum. Fifteen of them are reported between 1873 and 1890; six between 1890 and 1900; and seventeen between 1900 and the present time. The descriptions of the earlier cases are often faulty and one is left in doubt whether the tumor originated in the sternum or primarily in the clavicle or ribs. As to their point of origin in the sternum, seven are said to have arisen in the gladiolus, nine in the manubrium, two in the gladiolus and manubrium, and one in the xiphoid. The remaining twenty are simply described as arising from the sternum. One of these almost certainly had its origin in the inner end of the clavicle. The pathological descriptions also are often faulty. Thirteen cases are simply designated as sarcomas; seven additional cases are described as myxosarcoma, one; melanosarcoma, one; fibro-myxosarcoma, one; round-cell sarcoma, two; and spindle-cell sarcoma, two. The remaining eighteen cases form pathologically a heterogeneous group: gumma, one; "fibroid" tumor, three; chondroma (including my case), three; carcinoma, two; hypernephroma, two; "malignant thyroid tumor," one; vascular tumor or aneurism, one; and chronic inflammation, one. In one case (Weinlechner) two apparently different tumors of the sternum occurred in the same patient; one a primary chondroma of fifty years' duration, the other a "colloid sarcoma" of three years' duration. In three cases the pathological diagnosis of the tumor is not stated.

Of the thirty-eight tumors of the sternum, therefore, nineteen, or 50 per cent., are primary sarcomas; and to this number probably should be added the three so-called "fibroid tumors." Three or possibly four (12 per cent.) are primary cartilaginous tumors (chondroma; enchondroma; chondromyxoma), one is a gumma, and one is a chronic inflammatory lesion. The remaining seven tumors (18 per cent.) in which a diagnosis is stated are secondary, metastatic lesions. Of these, three were pulsating tumors and the primary diagnosis was aneurism. In one, the diagnosis of hypernephroma was con-

firmed by biopsy, in a second, the diagnosis of hypernephroma was established by necropsy; in the third, a positive diagnosis was not established.

It will be seen from this summary that the primary cartilaginous tumors of the sternum are rare, the case just described by me being the third or possibly the fourth to be reported.*

Of the thirty-eight cases, thirty-four were subjected to a more or less radical operation, two to a biopsy for diagnostic purposes, and one to radium treatment. One was not treated.

Of the thirty-four cases subjected to a more or less radical operation, eight died within fifteen days of the operation, and twenty-three recovered. In three cases neither the immediate nor late result of the operation is given. Of the twenty-three cases which recovered, three failed to show evidence of recurrence from one to two years and were living at the time of the report. Nine cases presented recurrences from one month to two years after operation from which six died. In ten cases the end-result is not given. The single case which is known from the reports in the literature to have survived beyond a two-year period is one, not of tumor, but of chronic inflammation. Of the three cases of enchondroma subjected to operation, one died five days after operation from pyæmia, and two showed recurrences or metastases within a year after operation.

A brief summary of the cases of tumor of the sternum thus far reported is appended.

CASE I.—Holden: Brit. Med. Jour., vol. xi, p. 358, 1878. A woman, aged fifty-two, with a sarcoma involving the gladiolus. At operation the tumor was partially removed. Details of the operation are lacking. Neither the immediate nor the late results of the operation are given.

CASE II.—König: Centralb. f. Chir., No. 42, 1882. A woman, aged thirty-six, with a sarcoma of the sternum. At operation the gladiolus, a part of the manubrium, the second to the eighth ribs on the left and the ends of the cartilages on the right were resected. Both internal mammary arteries were ligated. The pericardium was opened. Both pleuræ were opened (openings probably small) causing slight respiratory difficulty and tachycardia. The management of the bilateral pneumothorax is not stated. The patient recovered but died two years later from recurrences in the lungs. Paget commenting upon this case states that the patient died one year after operation from rheumatic fever.

CASE III.—Küster: Berlin klin. Wchnschr., p. 127, 1882. A man, aged thirty, with a tumor, later diagnosed a gumma, of the sternum. At operation the right half of the gladiolus and the third and fourth ribs were resected. One pleural cavity was slightly opened. Whether or not respiratory or cardiac disturbances followed is not stated. The patient recovered from the operation. The late result is not given.

CASE IV.—Pfeiffer: Beitrag z. Kennt. d. Sternal Tumoren, Halle, 1884. A man, aged forty-five, with a sarcoma of the gladiolus. At operation, the gladiolus and the second, third and fourth ribs right and left were resected. The right pleura was opened and probably also the pericardium. The patient developed an acute pericarditis and

* The fourth case I have in mind is that of Gangolph et Tixier in Lyon Chir., vol. ii, p. 112, 1909-1910, under the title of "Enorme Enchondrome de la fourchette sternale. Resection de la moitié supérieure du Sternum, etc." Unfortunately, this reference at the moment is not available.

the original operation because the left pleural cavity was not opened. But the mediastinum, the right pleural cavity and the right lung were thoroughly examined at operation and no evidence of metastases found. Is it possible that the numerous nodules in the mediastinum found by Doctor Carter represent implantations due to the rupture of the original tumor during its removal?

DISCUSSION OF TUMORS OF THE STERNUM

Zinninger (*ANNALS OF SURGERY*, vol. xcii, p. 1043, 1930) collected the cases of tumors of the thoracic wall between the time of my studies (1927) and 1930. He found twenty additional cases reported and to this number added eight from the records of the Peiping Medical School. He brings the total number of tumors of the thoracic wall reported in the literature up to 266. I have again gone over the literature with special reference to tumors of the sternum, and, including the case I have just recorded, find thirty-eight cases which are reported and described as tumors of the sternum. Fifteen of them are reported between 1873 and 1890; six between 1890 and 1900; and seventeen between 1900 and the present time. The descriptions of the earlier cases are often faulty and one is left in doubt whether the tumor originated in the sternum or primarily in the clavicle or ribs. As to their point of origin in the sternum, seven are said to have arisen in the gladiolus, nine in the manubrium, two 'in the gladiolus and manubrium, and one in the xiphoid. The remaining twenty are simply described as arising from the sternum. One of these almost certainly had its origin in the inner end of the clavicle. The pathological descriptions also are often faulty. Thirteen cases are simply designated as sarcomas; seven additional cases are described as myxosarcoma, one; melanosarcoma, one; fibro-myxosarcoma, one; round-cell sarcoma, two; and spindle-cell sarcoma, two. The remaining eighteen cases form pathologically a heterogeneous group: gumma, one; "fibroid" tumor, three; chondroma (including my case), three; carcinoma, two; hypernephroma, two; "malignant thyroid tumor," one; vascular tumor or aneurism, one; and chronic inflammation, one. In one case (Weinlechner) two apparently different tumors of the sternum occurred in the same patient; one a primary chondroma of fifty years' duration, the other a "colloid sarcoma" of three years' duration. In three cases the pathological diagnosis of the tumor is not stated.

Of the thirty-eight tumors of the sternum, therefore, nineteen, or 50 per cent., are primary sarcomas; and to this number probably should be added the three so-called "fibroid tumors." Three or possibly four (12 per cent.) are primary cartilaginous tumors (chondroma; enchondroma; chondromyxoma), one is a gumma, and one is a chronic inflammatory lesion. The remaining seven tumors (18 per cent.) in which a diagnosis is stated are secondary, metastatic lesions. Of these, three were pulsating tumors and the primary diagnosis was aneurism. In one, the diagnosis of hypernephroma was con-

firmed by biopsy, in a second, the diagnosis of hypernephroma was established by necropsy; in the third, a positive diagnosis was not established.

It will be seen from this summary that the primary cartilaginous tumors of the sternum are rare, the case just described by me being the third or possibly the fourth to be reported.*

Of the thirty-eight cases, thirty-four were subjected to a more or less radical operation, two to a biopsy for diagnostic purposes, and one to radium treatment. One was not treated.

Of the thirty-four cases subjected to a more or less radical operation, eight died within fifteen days of the operation, and twenty-three recovered. In three cases neither the immediate nor late result of the operation is given. Of the twenty-three cases which recovered, three failed to show evidence of recurrence from one to two years and were living at the time of the report. Nine cases presented recurrences from one month to two years after operation from which six died. In ten cases the end-result is not given. The single case which is known from the reports in the literature to have survived beyond a two-year period is one, not of tumor, but of chronic inflammation. Of the three cases of enchondroma subjected to operation, one died five days after operation from pyæmia, and two showed recurrences or metastases within a year after operation.

A brief summary of the cases of tumor of the sternum thus far reported is appended.

CASE I.—Holden: *Brit. Med. Jour.*, vol. xi, p. 358, 1878. A woman, aged fifty-two, with a sarcoma involving the gladiolus. At operation the tumor was partially removed. Details of the operation are lacking. Neither the immediate nor the late results of the operation are given.

CASE II.—König: *Centralb. f. Chir.*, No. 42, 1882. A woman, aged thirty-six, with a sarcoma of the sternum. At operation the gladiolus, a part of the manubrium, the second to the eighth ribs on the left and the ends of the cartilages on the right were resected. Both internal mammary arteries were ligated. The pericardium was opened. Both pleuræ were opened (openings probably small) causing slight respiratory difficulty and tachycardia. The management of the bilateral pneumothorax is not stated. The patient recovered but died two years later from recurrences in the lungs. Paget commenting upon this case states that the patient died one year after operation from rheumatic fever.

CASE III.—Küster: *Berlin klin. Wchnschr.*, p. 127, 1882. A man, aged thirty, with a tumor, later diagnosed a gumma, of the sternum. At operation the right half of the gladiolus and the third and fourth ribs were resected. One pleural cavity was slightly opened. Whether or not respiratory or cardiac disturbances followed is not stated. The patient recovered from the operation. The late result is not given.

CASE IV.—Pfeiffer: *Beitrag z. Kennt. d. Sternal Tumoren*, Halle, 1884. A man, aged forty-five, with a sarcoma of the gladiolus. At operation, the gladiolus and the second, third and fourth ribs right and left were resected. The right pleura was opened and probably also the pericardium. The patient developed an acute pericarditis and

* The fourth case I have in mind is that of Gangolph et Tixier in *Lyon Chir.*, vol. ii, p. 112, 1909-1910, under the title of "Enorme Enchondrome de la fourchette sternale. Resection de la moitié superieure du Sternum, etc." Unfortunately, this reference at the moment is not available.

pleuritis and died on the sixth post-operative day. The autopsy showed other tumors on the fourth rib and metastases in the aortic glands, liver and right kidney.

CASE V.—Bardenheuer: Deutsch. Med. Wchnschr., vol. xi, p. 688, 1885. A woman of unstated age with a "fibroid" tumor of the manubrium. At operation the manubrium, two-thirds of the clavicle and the second and third ribs were resected. There are no details regarding the opening of the pleura. The patient recovered. The late result is not given.

CASE VI.—*Ibid.*—A man of unstated age with a sarcoma involving the manubrium but presumably arising from the inner end of the clavicle. At operation the manubrium, two-thirds of the clavicle and the first and second ribs were resected. The internal jugular vein was torn during the operation and the right innominate, subclavian and internal and external jugular veins ligated. The patient recovered from the operation. The late result is not stated.

CASE VII.—*Ibid.*—A patient with a tumor presumably of the manubrium. The nature of the tumor is not stated. At operation the manubrium was resected. The patient recovered. No other details given.

CASE VIII.—*Ibid.*—A patient with a tumor presumably of the manubrium. The nature of the tumor is not stated. At operation the manubrium was resected. The patient died. No other details are given.

CASE IX.—*Ibid.*—A patient with a tumor presumably of the manubrium. The nature of the tumor is not stated. At operation the manubrium was resected. The patient died. No other details are given.

CASE X.—*Ibid.*—A woman with a retrosternal "fibroid" tumor involving the manubrium, part of the gladiolus, the first and second ribs and the inner end of the clavicle. At operation these structures were resected. The patient recovered. The late result is not given.

CASE XI.—*Ibid.*—A patient with a retrosternal "fibroid" tumor involving the manubrium, part of the gladiolus, the first and second ribs and the inner end of the clavicle. Resection of these structures. The patient recovered. The late result is not given.

CASE XII.—Jaenel: Inaug. Diss. Erlangen, 1887. A girl of twelve years with a sarcoma of the manubrium. At operation the manubrium and the first and second ribs were resected. The retrosternal tissues were found involved and were cauterized with the actual cautery and nitric acid. The patient recovered. There was no recurrence at the end of one year.

CASE XIII.—Dudon: Jour. de Med. de Bordeaux, June 1, 1890. A woman, twenty-eight years of age, with an enchondroma of the gladiolus. A previous operation, the details of which are scanty, had been performed twenty-seven months before. At the second operation, eight months after the first, the manubrium, part of the gladiolus and the first and second ribs were resected. The wound suppurated. The patient recovered. The last report indicated recurrences in the pectoral and sternomastoid muscles.

CASE XIV.—Mazzoni: Cited by Dudon above. A man, fifty-five years of age, with a myxosarcoma of the gladiolus. At operation the gladiolus and the second, third and fourth ribs were resected. The patient died fifteen days after operation from pneumonia. No other details given.

CASE XV.—Graves: Med. News, vol. lxii, p. 241, 1893. A woman, aged forty-four, with a sarcoma of the gladiolus. At operation the gladiolus and the second, third, fourth and fifth ribs were resected. The history relates that a breast had been removed twenty-two months previously for carcinoma which casts some doubt upon the diagnosis of sarcoma. The patient recovered from the operation. The late result is not given.

CASE XVI.—Doyen: Arch. Prov. de Chir., vol. iv, p. 633, 1895. A man, aged thirty-seven, with a sarcoma of the manubrium. At operation the manubrium, parts of

both clavicles and the first rib were resected. Neither pleura was opened. The patient recovered. The late result is not given.

CASE XVII.—Mynter: *ANNALS OF SURGERY*, vol. xiii, p. 96, 1891. A woman, aged twenty, with a melanosarcoma of the gladiolus. At operation the gladiolus and the third, fourth and fifth ribs were resected. The subclavian and axillary glands on both sides were removed. The patient recovered but died one year later presumably from metastases.

CASE XVIII.—Keen: *Med. and Surg. Reporter*, vol. lxxvi, March, 1897. A woman, aged twenty-eight, with a sarcoma of the manubrium. At operation, the manubrium, one-third of the clavicle, first rib and one-third of the sternomastoid muscle were resected. The wound suppurated. The patient recovered. There was no evidence of recurrence fifteen months after operation. Later reports not available.

CASE XIX.—*Ibid.*—A woman, aged forty-four, with a carcinoma of the manubrium and gladiolus. The condition was secondary to carcinoma of the breast. At operation a partial resection of the manubrium, gladiolus and second and third ribs was accomplished. The patient recovered from the operation but died five months later.

CASE XX.—Weinlechner: *Bericht d. K.K. Krankanstl. Rud. Stift in Wien*, p. 124, 1873. A man, aged fifty-eight, who is stated to have had two distinct tumors of the sternum, one, a primary chondroma of fifty years' duration, the other a colloid sarcoma of three years' duration. At operation what appears to have been only a local excision of the tumors was undertaken. The wound became infected and the patient died on the fifth post-operative day from pyæmia.

CASE XXI.—König: *Inaug. Diss.*, 1894. A man, aged fifty-nine, with a sarcoma the size of a "fist" involving the sternum. At operation the sternum and the second to the fifth ribs on both sides were resected. During the operation an opening the size of a "five-mark piece" was made in the right pleura. There was at first no respiratory or cardiac upset but subsequently dyspnœa and feeble pulse appeared. The patient died. At necropsy he was found to have brown atrophy of the heart.

CASE XXII.—Amburger: *Beitr. z. Klin. Chir.*, vol. xxx, p. 770, 1901. A man, aged forty-seven, with a round-cell sarcoma of the sternum. The tumor measured three by nine by eleven centimetres in its various diameters. At operation the manubrium and the first and second ribs were resected. Both pleuræ were opened during the operation but the size of the openings is not stated. No untoward symptoms followed. The patient died three days after operation.

CASE XXIII.—*Ibid.*—A man, aged thirty-seven, with a round-cell sarcoma (size of goose egg) of the sternum. At operation the gladiolus and three ribs were resected. The pleura was not opened. The patient recovered but subsequently died from metastases.

CASE XXIV.—*Ibid.*—A woman, aged twenty-two, with a spindle-cell sarcoma (size of apple) of the sternum. At operation the manubrium and the first and second ribs were resected. The left pleura was opened but the size of the opening is not stated. No upset followed. The patient recovered and at the expiration of two years there was no evidence of recurrence.

CASE XXV.—*Ibid.*—A man, aged forty, with a fibromyxosarcoma involving the sternum, the mediastinum and the pectoral muscle. The tumor was of seventeen years' duration and had attained the size of a "fist." At operation the manubrium and the second and third ribs were resected. The left pleura was opened but no disturbance followed. The patient recovered. One year later he died from a hæmorrhage from a recurrence which had reached the size of a child's head.

CASE XXVI.—Morestin: *Bull. de la Soc. Anat. de Paris*, vol. lxxvii, p. 414, 1902. A woman of unstated age with a sarcoma of the sternum. Her breast had been amputated for sarcoma seven months previously. At operation the manubrium was resected. The result is not given.

CASE XXVII.—Mayer: *Jour. Med. de Brux.*, vol. ix, p. 146, 1904. A woman, aged thirty-eight, with a sarcoma of the sternum. At operation the sternum and the three

upper ribs were resected. A double pneumothorax was produced during the operation, the effects of which are not stated. The patient developed empyæma and died nine days after operation.

CASE XXVIII.—Isaacs: *Am. Jour. Surg.*, vol. xxiii, p. 291, 1909. A woman, aged forty-six, with a spindle-cell sarcoma of the sternum (size of hen's egg). At operation the sternum below the level of the second costal cartilage was resected. A pneumothorax was produced but no details are given. Pneumonia complicated the convalescence. The patient recovered but presented a recurrence and metastases one month after operation.

CASE XXIX.—Lamphear: *Surg., Gynec., and Obst.*, vol. xiv, p. 619, 1912. A woman, aged sixty-one, with a carcinoma of the sternum. At a two-stage operation the manubrium and a part of the clavicle were resected. A pneumothorax was not produced. The patient recovered. The late result is not stated.

CASE XXX.—Richardson: *Brit. Med. Jour.*, vol. i, p. 985, 1913. A man, aged twenty-six, with a chondroma of the manubrium. The tumor was of long duration but had recently grown rapidly. At operation the manubrium was resected. The patient recovered. The late result is not stated.

CASE XXXI.—Le Jars: *Le Semaine Med.*, vol. xxxiv, p. 16, 1914. A man, aged forty, with a sarcoma, four to five inches in diameter, involving the xiphoid. At operation the xiphoid was resected. The result is not given.

CASE XXXII.—Hedblom: *Arch. Surg.*, vol. iii, p. 56, 1921. A woman, aged fifty-three, with a tumor of the manubrium. At operation the manubrium was resected. The tumor proved to be the result of a chronic inflammatory process. The patient recovered. There has been no recurrence.

CASE XXXIII.—McLeod and Jacobs: *Med. Rec. N. Y.*, vol. c, p. 979, 1921. A man, aged fifty-four, with a pulsating tumor, the size of "one-half an orange," involving the sternum. A diagnosis of aneurism was first made. A biopsy for diagnostic purposes showed the tumor to be a hypernephroma. No further operation done. The patient died some time later. An autopsy was not obtained.

CASE XXXIV.—*Ibid.*—A man, aged sixty-nine, with a pulsating tumor, 3½ by 6 inches in size, involving the sternum. A diagnosis of aneurism was made. The patient died some six weeks after coming under observation. The autopsy showed a hypernephroma with a metastasis in the sternum.

CASE XXXV.—Maingot: *Brit. Med. Jour.*, vol. i, p. 140, 1926. A woman, aged seventy-three, with a tumor 3 by 2½ inches in diameter involving the manubrium. A biopsy showed a "malignant thyroid tumor." Clinically, there was no evidence of thyroid disease. The result is not stated.

CASE XXXVI.—Griffith: *Lancet*, London, vol. ii, p. 991, 1902. A patient with a large sarcoma of the sternum. At operation the sternum from the second to the seventh costal cartilages was resected. The growth was not completely removed. A large opening in the pleura was produced which gave rise to slight shock. The patient recovered from the operation but died four months later, presumably from a continuance of the disease.

CASE XXXVII.—Zinninger: *ANNALS OF SURGERY*, vol. xcii, p. 1043, 1930. A male Chinese, aged forty-seven, with a tumor the size of a hen's egg involving the sternum. The tumor pulsated and was thought to be either a vascular sarcoma or an aneurism. A radium pack was applied but without improvement. The outcome is unknown.

CASE XXXVIII.—Heuer.—See above.

THE SURGICAL TREATMENT OF MEDIASTINAL TUMORS

REMOVAL OF CYSTIC AZYGOS LOBE FROM POSTERIOR MEDIASTINUM

BY STUART W. HARRINGTON, M.D.

OF ROCHESTER, MINN.

THE incidence of intrathoracic tumors is probably no greater now than it has ever been, but in recent years they are being recognized more frequently, due to the marked improvement that has been made in methods of thoracic diagnosis, especially since the use of Röntgen-rays. Early diagnosis of these tumors, before the growth has made serious inroads on the patient's general condition, has been the greatest aid to their surgical removal, and study of such proved cases has given a different conception of the type of lesion found in this region as well as of the prognosis. The older belief was that most of these growths were malignant, and that only conservative treatment was justified, because surgical treatment was an extremely hazardous procedure. The lack of response in so many of these cases to conservative treatment has encouraged surgical intervention with the view of complete removal of the growth, and the marked advancement in methods of surgical technic has made operative removal a relatively safe procedure. Microscopical study of the lesions removed has shown that a large percentage of intrathoracic tumors are benign.

A relatively high percentage of intrathoracic growths have their origin in the mediastinum. Because of the many different tissue elements in this space, it has the potential possibility of presenting almost any type of neoplasm. In my experience of thirty-eight cases in which intrathoracic new growths were removed by operation, twenty-three (61 per cent.) were in the anterior or posterior mediastinum. Microscopical study of these twenty-three cases disclosed that eighteen (78 per cent.) were benign tumors of the following types: eight were neurofibromas, in three of which there was lipoid degeneration; two were cellular fibromas; seven were teratomas, one of the dermoid type and one presenting sufficient organoid structure to be designated as a parasitic foetus, and one, the eighteenth, a congenital cyst of the lung. The last case is reported in this paper. The remaining five tumors of the mediastinum (22 per cent.) were malignant, of which one tumor was a squamous-cell epithelioma which probably arose by malignant degeneration of a dermoid tumor of the anterior mediastinum; three tumors were fibrosarcomas, two of which were probably primarily benign tumors, and one, the fifth, was an adeno-carcinoma of intrathoracic thyroid tissue, with erosion of the spine. All mediastinal tumors are potentially malignant. The high percentage of benign tumors in this series is probably due to removal of the growth, before it had undergone malignant change. The clinical history of three of the five patients who had malignant tumors sug-

gested that the tumor had been benign at the onset and had undergone malignant degeneration.

Tumors that remain benign often attain enormous size, and may cause death from mechanical pressure on the numerous important structures in the potential spaces designated as the mediastinum. These structures either control, or are closely associated with, respiration; circulation of arterial and venous blood and lymph; deglutition, and functional innervation of organs lying outside the thorax. Inasmuch as the mediastinum is only a potential space, growths arising in this region will impinge on the anatomically adjacent structures, depending on the situation of the lesion, such as the lungs, vertebræ, diaphragm and structures at the base of the neck. Because of the important structures contained in the mediastinum it is of paramount importance that these tumors be recognized and treatment instituted before the growth has caused serious and permanent injury to these vital structures, as well as disturbing the function of all the viscera within the thorax.

There is great variation in the subjective symptoms produced by mediastinal neoplasms. The symptoms are dependent on the type of growth, but more on the situation than on the size of the tumor. They are due to pressure or infiltration of the involved or surrounding structures in the region invaded, and on the amount and severity of disturbed function of intrathoracic organs. If the symptoms appear early, it may be possible to make a diagnosis by the history and general examination only, but it is extremely rare more than to suspect the presence of a tumor on the basis of these observations. Most cases can be definitely diagnosed only by aid of Röntgen-rays, whether or not they produce symptoms, and regardless of physical findings.

The most common symptoms and signs which cause the patient to consult the physician are as follows: Pain; dyspnœa; cough; various degrees of cyanosis caused by pressure on the lungs, heart, great vessels or nerves; displacement of the heart from pressure; dilatation of the veins over the thorax, and distention of the jugular vein from pressure on the superior vena cava; dysphagia from extrinsic pressure on the œsophagus; changes in the voice from pressure on the recurrent laryngeal nerve; unilateral sweating and flushing of the face associated with enophthalmus, visual disturbance, inequality in the size of the pupils, and ptosis of one eyelid from pressure on the sympathetic nerves; nerve pain, root pain, and herpes from pressure erosion of the spinal column and spinal cord; difference in size of the two sides of the thorax; decrease or absence of motion of one side of the thorax during inspiration; loss of weight; anorexia; pyrexia, and evidence of pleural effusion or empyæma.

Pain is probably the most significant symptom in the clinical distinction between an early malignant lesion and a benign lesion. From malignant growths of small size the pain is often very severe, and may be more or less constant, but with acute exacerbations at irregular times, usually most severe at night.

Benign tumors may often attain great size without producing pain other

than a dull ache or a sense of pressure accompanied by dyspnoea on exertion. Benign, anterior mediastinal tumors usually present more subjective symptoms than benign posterior tumors because of the limited space anteriorly, and these tumors are usually fixed to the heart and great vessels. The most common benign anterior mediastinal tumors are teratomas, which often produce pain as a result of inflammatory irritation associated with respiratory infections; the diagnosis commonly is pleurisy or pneumonia. The most common growths in the posterior mediastinum are neurofibromas and cellular fibromas, which may attain considerable size without causing pain unless the tumor is of the dumb-bell type, causing erosion of the spinal column with associated root pain and symptoms referable to the spinal cord, depending on the portion of the spine involved.

Dyspnoea is one of the most common symptoms of benign or malignant tumors, is usually present with early lesions, and is most noticeable on exertion. It is caused by pressure on the lungs, particularly at the hilum, also by pressure on the heart, great vessels, and nerves. It may be constant or paroxysmal, and is often the only subjective symptom.

Cough is a frequent early symptom of malignant lesions, and it is often paroxysmal and of a hoarse or brassy type. It may be nonproductive, but usually is associated with expectoration of mucus or blood. The type of expectoration may be of great diagnostic importance, as in the presence of dermoid or teratoid growths which have ruptured into a bronchus, with expectoration of sebaceous material, hair, and occasionally tumor tissue and pus from secondary infection. Expectoration of this material often occurs at night, and may be associated with violent attacks of coughing and pain simulating attacks of strangulation.

Horner's ocular syndrome was noted in three cases, in all of which the growths were malignant, which would suggest that the syndrome was due to malignant infiltration rather than to pressure on the sympathetic nerves. I have removed several benign tumors of much larger size from the same region in cases in which Horner's syndrome was not present.

The physical signs are often helpful in determining the presence of a lesion but are unreliable as to its extent or character. Vocal fremitus will usually be increased over the tumor, and with this there is usually an area of definite dullness and absence of breath sounds. In the presence of anterior mediastinal tumors the heart is often displaced and the sounds are transmitted over a wide area. All of the usual physical signs of regions of consolidation in the thorax may be absent and a tumor of considerable size may be present but produce no evidence either by symptoms or on general examination.

In most instances, the greatest amount of information that can be expected to be obtained from the clinical history and the physical signs is that of the probable presence of a mediastinal tumor, and its approximate situation. In order to determine accurately the position and size of the growth and its relation to the normal content of the mediastinum and thorax, resort must be had to other methods of examination. The most

important of these is röntgenological examination of the thorax. This should be made in the anteroposterior, oblique, and true lateral positions, and its value is greatly enhanced by stereoscopic films. In certain cases, additional information can be obtained from röntgenological examination after establishment of artificial pneumothorax, after injection of the bronchial tree with iodized oil, or after introduction into the œsophagus of a preparation of barium. Fluoroscopical examination is of value in determining the relation of the tumor to the surrounding normal structures, and in determining whether it is encroaching on, or is causing, impairment of function of these structures. It is also of importance in the differential diagnosis of tumors and aneurism.

Bronchoscopical examination is of value in ruling out the presence of a primary intrabronchial lesion, or in determining whether there is encroachment of an extrinsic growth on the lung. Œsophagoscopical examination is of value in ruling out the presence of a primary lesion of the œsophagus, or in determining if there is encroachment of an extrinsic lesion on the œsophagus.

Thoracoscopical examination may be advisable in selected cases of posterior mediastinal tumor in which the growth projects well into the thoracic cavity. In this way, the situation of the tumor can be determined, and in some instances a specimen of the tumor may be removed for microscopical examination. However, in most of these cases, I prefer to perform exploratory thoracotomy. In cases of anterior mediastinal tumor, it is rarely, if ever, advisable. Diagnostic thoracentesis, with an aspirating needle, may be justified in certain rare cases, such as when the available evidence is that of a cyst adherent to the thoracic wall, or to aid in distinguishing between such a cyst and an encapsulated accumulation of fluid in the pleural cavity. This procedure is rarely, if ever, advisable in cases of anterior mediastinal tumor, because of the danger of mediastinal infection entailed, in any case, at inserting a needle into the mediastinum, and especially because of the possible risk of injury to an aneurism of the arch of the aorta.

In some cases, differential diagnosis of malignant and benign disease remains in doubt after all of the armamentarium of modern thoracic diagnosis has been exhausted. In some cases of malignant disease there may be involvement of the regional superficial lymph-nodes, and one of these can be removed for microscopical examination to establish the correct diagnosis, but in many cases there is no enlargement of regional lymph-nodes. In some cases of this latter group, in which the tumor is unilateral and the available evidence is more characteristic of a malignant growth of the type of lymphoblastoma, treatment of the growth with Röntgen-rays is often of diagnostic value, for these tumors are radiosensitive and will appreciably diminish in size from a week to ten days after irradiation. In cases of benign tumor there will be no appreciable change in the size or contour of the tumor following irradiation. The differential diagnosis of mediastinal tumor and aneurism of the aorta usually can be made on the basis of the clinical symp-

MEDIASTINAL TUMORS

toms which are associated with aneurism, and by means of fluoroscopical examination of the thorax. In fluoroscopical examination, care must be exercised not to confuse the pulsation of an aneurism with that of the transmitted pulsation from the arch of the aorta onto the tumor. In those cases in which the diagnosis cannot be established even after all available methods have been utilized, exploratory thoracotomy is indicated, depending on the patient's general condition.

The chief problems associated with surgical removal of mediastinal tumors are concerned with the danger of pulmonary collapse, with mediastinal flutter resulting from open pneumothorax, and the difficulty of access through the bony encasement of the thorax. The first of these hazards has been greatly diminished by the use of differential air-pressure during the operation. The second is entirely a technical problem, and methods of approach are continually being improved and perfected.

Surgical indications depend on the findings in each case. Patients who are selected for surgical intervention should be placed in the hospital under observation and pre-operative preparation for approximately one week before operation. After bronchoscopical or thoracoscopical examination has been made, the operation should be delayed for at least three to five days. I believe that the operative risk is decreased by establishment of artificial pneumothorax approximately five days before operation, to permit the patient to become accustomed to unilateral partial pulmonary collapse, and decreased vital capacity. In my series of twenty-three cases, including anterior and posterior mediastinal tumors, preliminary artificial pneumothorax was established in eleven. In some instances it will be impossible to establish artificial pneumothorax because of adhesion of the lung to the tumor, or to the thoracic wall, which will prevent collapse of the lung. In the pre-operative period the patient should be given at least 3,000 cubic centimetres of fluid daily.

I prefer to use intratracheal anæsthesia under positive pressure. I have operated with intrapharyngeal anæsthesia, with the closed mask, and without positive pressure of the anæsthetic agent, without harmful results. It is probable that intrapharyngeal anæsthesia would be satisfactory in most cases in which one pleural cavity is opened, but it is never possible to determine before operation what emergency may arise, or when the opposite pleural cavity may be opened unavoidably. I believe that anæsthesia by intratracheal insufflation, and administered with apparatus for positive pressure, is the safest method in most cases; this method was used in most of the twenty-three cases mentioned. The anæsthetic agents were ethylene and ether or ethylene alone, in all cases. Many of these operations are long and tedious, and it is important to ventilate and reestablish circulation by fully expanding the lung every three to five minutes during the operation. The amount of pressure used is gauged by a water manometer on the positive-pressure apparatus. The lung is fully inflated at the completion of the operation. A

suction pump is applied to the intratracheal catheter during its withdrawal to remove any mucus which may have accumulated in the trachea.

The surgical approach through the thoracic bony cage depends on the site and size of the tumor. To reach anterior mediastinal tumors, it may be through the anterior or posterior thoracic wall. Nine of the twenty-three mediastinal tumors in my experience were in the anterior mediastinum. In two of these cases the tumor was approached through the anterior thoracic wall, and in one of them the clavicle was cut in order to approach the tumor at the apex. In the remaining seven cases, the approach was made through the posterior thoracic wall through a posterolateral incision around the vertebral border of the scapula, and entering the pleural cavity through the deep layer of periosteum after resecting one rib. The vertical level of the incision in the pleura depends on the situation of the tumor; that is, whether it is high or low in the mediastinum. If more exposure is necessary in order to remove the tumor, the ribs can be cut close to the spinal column, both above and below the resected rib, together with the intercostal muscles, until sufficient exposure has been obtained to remove the growth from its attachment and to deliver the tumor through the wound. At completion of the operation the cut ends of the ribs are sutured by drilling through them and suturing them together with chromic catgut. In all of the fourteen cases in which the tumor was in the posterior mediastinum, the posterior approach was used. I prefer this method of approach in all cases of mediastinal tumor, unless the tumor causes so much pressure in the anterior mediastinum that the growth is firmly fixed to and has caused marked deformity of the thoracic wall. In some of these cases it may be advisable to make the incision over the site of the tumor. In nineteen cases the tumor was removed by transpleural operation. In four cases it was removed by extrapleural operation; two of these tumors were removed through an anterior incision, and two through a posterior incision. A posterior, extrapleural operation was attempted in several other cases, but such an operation is rarely possible because of adhesions of the pleura to the tumor; these were usually so firm that the pleura was ultimately entered before the tumor could be completely removed, thus subjecting the patient to all of the dangers of open pneumothorax, and in addition to the probability of extensive pleural effusion due to the wide separation of the pleura from the thoracic wall. I believe that there is less risk in performing an initial transpleural operation in most cases. In all cases, the tumor was completely removed in a one-stage operation. This I believe to be the operation of choice, for the technical difficulties are usually increased by operations in multiple stages, which increase the danger of the operative procedure.

The blood-pressure should be taken every five minutes during the operation. When there has been a fall of ten millimetres of mercury in the pulse-pressure, physiological solution of sodium chloride or solution of acacia is given intravenously. If the pulse-pressure drops twenty to thirty millimetres of mercury, transfusion of blood is given.

MEDIASTINAL TUMORS

Post-operative care is very important. Maintenance of bodily heat is essential, both when the patient is on the operating table, and after operation. The most significant immediate complication is dyspnoea with cyanosis. If this occurs, the patient is placed immediately in the oxygen chamber. This often proves to be a life-saving procedure, for it tides the patient over the critical period of decreased vital capacity of the lungs. This was particularly exemplified in one case, in which a large teratoma was removed from the anterior mediastinum; the growth had extended into the right thoracic cavity, causing almost complete collapse of the right lung and displacement of the heart into the left thoracic cavity from pressure. Because of marked decrease in vital capacity following operation it was necessary to keep the patient in the oxygen chamber for three weeks. Five attempts were made to remove the patient from the oxygen chamber before such removal was finally accomplished after the gradual decrease of the percentage of oxygen over a period of ten days. The oxygen chamber was used in sixteen of my twenty-three cases. Later complications are pleural effusion and empyæma. In practically all cases pleural effusion develops, but in a few of the cases aspiration is not required. In about a third of the cases pleural effusion will disappear after one aspiration, and in the remaining third it will require repeated aspiration. The frequency and persistence of pleural effusion depend on the type of tumor and the amount of trauma to the pleura. In cases of teratoma, pleural effusion is most likely to develop and may result in empyæma. Empyæma complicated the convalescence in five cases of this series of twenty-three; in all five cases drainage was accomplished by the closed method. In one case, subsequent open operation was required. In one case, convalescence was complicated by the development of osteomyelitis of a rib, with formation of a sequestrum, for which further resection of the rib and removal of the sequestrum was required. Convalescence was delayed in these cases, but all the patients recovered.

There were three operative deaths. One patient, who had a neurofibroma, died on the fourth day after operation from pneumonia and an associated bloody pleural effusion. The bloody pleural effusion resulted from diffuse oozing from the bed of the tumor where it had been adherent to the lung. The adhesions were probably the result of extensive Röntgen therapy, to which the patient had been subjected prior to her admission to the clinic because the tumor was thought to be malignant. The tumor did not become smaller, and I believe that any mediastinal tumor which does not undergo some reduction in size within the first week or ten days after irradiation, should not be treated further with Röntgen-ray if surgical intervention is contemplated. The second death occurred six days after operation, as a result of bronchopneumonia and hæmorrhage into the spinal cord. The tumor was a neurofibroma which had been present for more than five years. The patient was practically symptomless until three to six months before admission. A congenital condition of the heart with coarctation of the aorta also was present. At operation it was found that the tumor had eroded

through the vertebræ, causing pressure on the spinal cord, with marked dilatation of the vessels in the spinal cord. This dilatation of vessels was probably primarily due to coarctation of the aorta, and was augmented by pressure from the tumor. Following the operation, hæmorrhage developed from the vessels in the cord, requiring laminectomy in twenty-four hours. The erosion of the spinal column in this case exemplified the serious effect that benign tumors may have on the surrounding structures, which materially increases the operative risk and emphasizes the importance of early removal of the growths. The third death took place on the seventh day after operation, from cerebral embolism. The case was one of malignant degeneration of an anterior mediastinal dermoid. The possibility of malignant degeneration of tumors of this type manifests the importance of early diagnosis and removal.

Twenty patients recovered from operation; three died subsequent to operation; the tumors in these cases were malignant and the patients died from recurrence. One patient, who had a sarcoma which probably originated in the vertebra, died five months after operation from recurrence; two patients who had fibrosarcomas, and whose histories indicated benign tumors at the onset, died of recurrence, one, two and one-half years after operation, and the second, six months after operation. One patient who had a carcinoma of the thyroid gland with metastasis into the mediastinum is living at the present time, two years and four months after operation, but has a recurrence. Sixteen patients, all of whom had benign tumors, are living and completely relieved of symptoms from three months to six years after operation.

Cases of benign tumors are the most gratifying from a surgical standpoint, for the risk is not great if the tumors are removed before they have become so large as to cause pressure on the surrounding structures. If the patient survives the operation, complete cure is obtained. The frequency with which these tumors become malignant is the most significant indication for their early surgical removal. Because of the difficulty in establishing a definite clinical diagnosis, I believe that exploration should be made in all cases, unless the clinical evidence is that a hopeless, inoperable condition exists.

Following is a report of a recent case which is of unusual interest because of the uncommon occurrence of an azygos lobe and the infrequency with which such a lobe is the site of a pathological process. I have been unable to find in the literature a report of a similar case.

REPORT OF CASE.—A woman, aged thirty-seven years, first came to the clinic September 17, 1930, at which time she was found to have a large substernal goitre; this was removed September 23, 1930. In the course of her examination at this time, she complained of an indefinite pain in the upper right posterior portion of the thorax. Röntgenological examination (Figs. 1, 2 and 3) revealed fluid in an azygos lobe, the upper level of which was between the sixth and seventh ribs. There were no other subjective symptoms. She returned for observation December 31, 1931, at which time she stated that she had done very well following thyroidectomy, until April, 1931, which

was seven months after operation, when severe respiratory infection developed, associated with a sore throat. This was accompanied by increase in temperature and severe cough. She had never entirely recovered from the cough. The expectoration varied in quantity and was of yellowish, pus-like material which was very thick and tenacious. It varied in quantity from two to six ounces (60 to 180 cubic centimetres) daily, and was usually very difficult to raise. Often she coughed for a long period before this material could be expectorated. She believed the difficulty was due to the thick, sticky character of the material. There had never been any hæmorrhage, and only moderate pain, which was in the upper right portion of the thorax and was noted when there was difficulty in expectorating the mucoid material. She had been unable to work since the onset of her cough because of weakness and fatigue. She had lost six and one-half pounds in the previous six months.

Examination revealed systolic blood-pressure of 122 millimetres of mercury, and diastolic of 94. The pulse-rate was 104 beats each minute, and the temperature 98.1° F. Repeated examinations of sputum were negative for organisms of tuberculosis and actinomycosis. There was dullness to percussion, and many loud, bubbling râles were heard in the right portion of the thorax, at the level of the third rib anteriorly and from the seventh rib posteriorly to the apex. Röntgenological examination revealed a dense tumor in the upper right mediastinal region, corresponding in situation with the position of an azygos lobe, extending from the seventh to the second rib posteriorly, filling the entire posterior mediastinum and extending across the median line to the left border of the aorta. In the lateral stereoscopic view there was a dense, fusiform shadow in the midst of the upper right portion of the thorax, overlying the shadow of the spinal column. The lower border of the shadow gave evidence of communication between the structure which caused the shadow and a bronchus, at the hilum. A tentative diagnosis of infected congenital cystic tumor of the lung, probably a cystic azygos lobe, was made. Two bronchoscopic examinations were made, and at the first examination, January 5, 1932, a large quantity of pus was found exuding from the bronchus of the right upper lobe. It was impossible to remove all of the pus-like material, for it continued to pour down regardless of continuous aspiration. It apparently came from the posterior division of the bronchus of the right upper lobe. Lipiodol, thirty cubic centimetres, was injected into the bronchus of the upper right lobe. Bronchoscopy was done again January 11; a large amount of pus-like material was found exuding from the bronchus of the right upper lobe, and about 300 cubic centimetres of this material were aspirated and sent for bacteriological examination, culture, and inoculation of guinea-pigs. No organism was found in the stained specimen, nor was any growth obtained from the culture. After a requisite time, the guinea-pig was examined, but no evidence of tuberculosis was found. The patient was partially relieved of cough and expectoration for about twenty-four hours following the bronchoscopic aspiration, after which time the cough was the same as before. She was placed in the hospital under observation for a few days. She had no fever, but the cough and expectoration became gradually worse, and there seemed to be more pain in the upper right portion of the thorax, posteriorly. Surgical intervention was advised.

January 16, 1932, transpleural, posterior mediastinotomy was performed under intratracheal anæsthesia with ethylene. The posterior two-thirds of the sixth rib were removed, from the spine of the vertebra laterally, the fifth and fourth ribs were drilled and cut (Figs. 4 and 5), and the right pleural cavity was entered through the inner layer of periosteum of the sixth rib. There was a large cyst in the right lung, in the same relative position as an azygos lobe, involving the upper posterior part of the mediastinum, and involving about two-thirds of the upper right portion of the thorax. There was partial collapse of the upper and posterior parts of the right lung, which were very adherent to this cystic mass, and completely surrounded it laterally. The median portions of the upper and posterior parts of the lung were separated from the tumor, which was firmly adherent to the upper lobe, and had to be cut from it with a

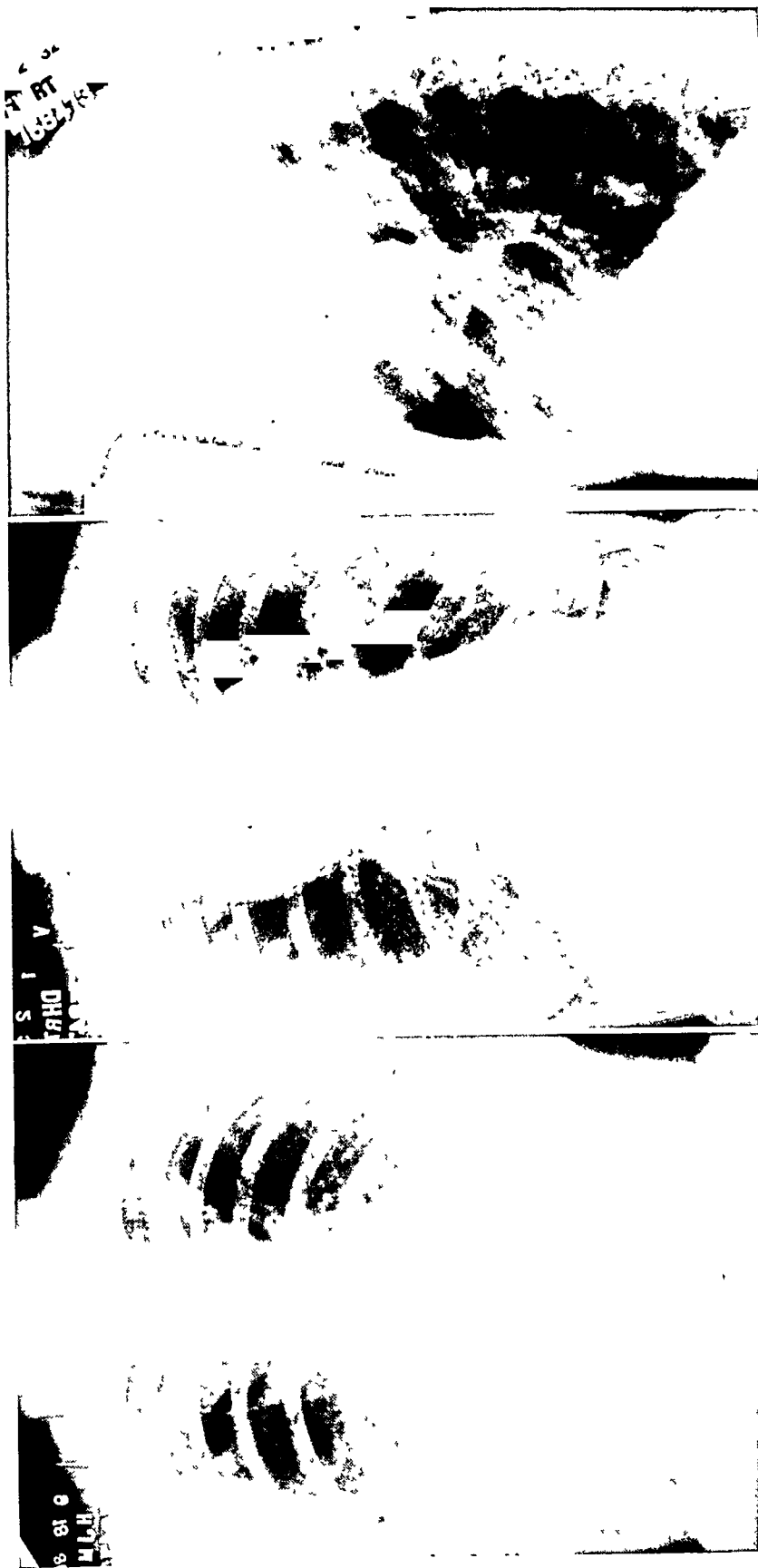


FIG. 1.

FIG. 2.

FIG. 3.

FIG. 1.—Roentgenogram on first admission. Large cystic azygos lobe in right upper portion of thorax. Upper level of fluid between sixth and seventh ribs, posteriorly, and extending across mediastinum to left border of aorta.

FIG. 2.—Roentgenogram on second admission. Dense tumor in upper, right, posterior mediastinal region, corresponding in situation with the position of an azygos lobe.

FIG. 3.—Lateral view. Dense fusiform shadow in the midst of the upper right portion of the thorax, overlying the shadow of the spinal column. The lower border of the shadow indicates that the tumor communicates with a bronchus at the hilum.

MEDIASTINAL TUMORS

knife. In several places the cyst had partially ruptured into the adjacent pulmonary tissue; these perforations were repaired by suture. The lower portion of the tumor, close to the hilum, was not adherent to the lung and was covered with visceral pleura similar to that of the lung. The cyst extended across the median line, into the left part of the mediastinum, and then to the left border of the aorta. It was thick-walled, dense, and contained about 750 cubic centimetres of thick, yellowish, pus-like material which contained a great deal of mucus. There was a large bronchial fistula emptying into the

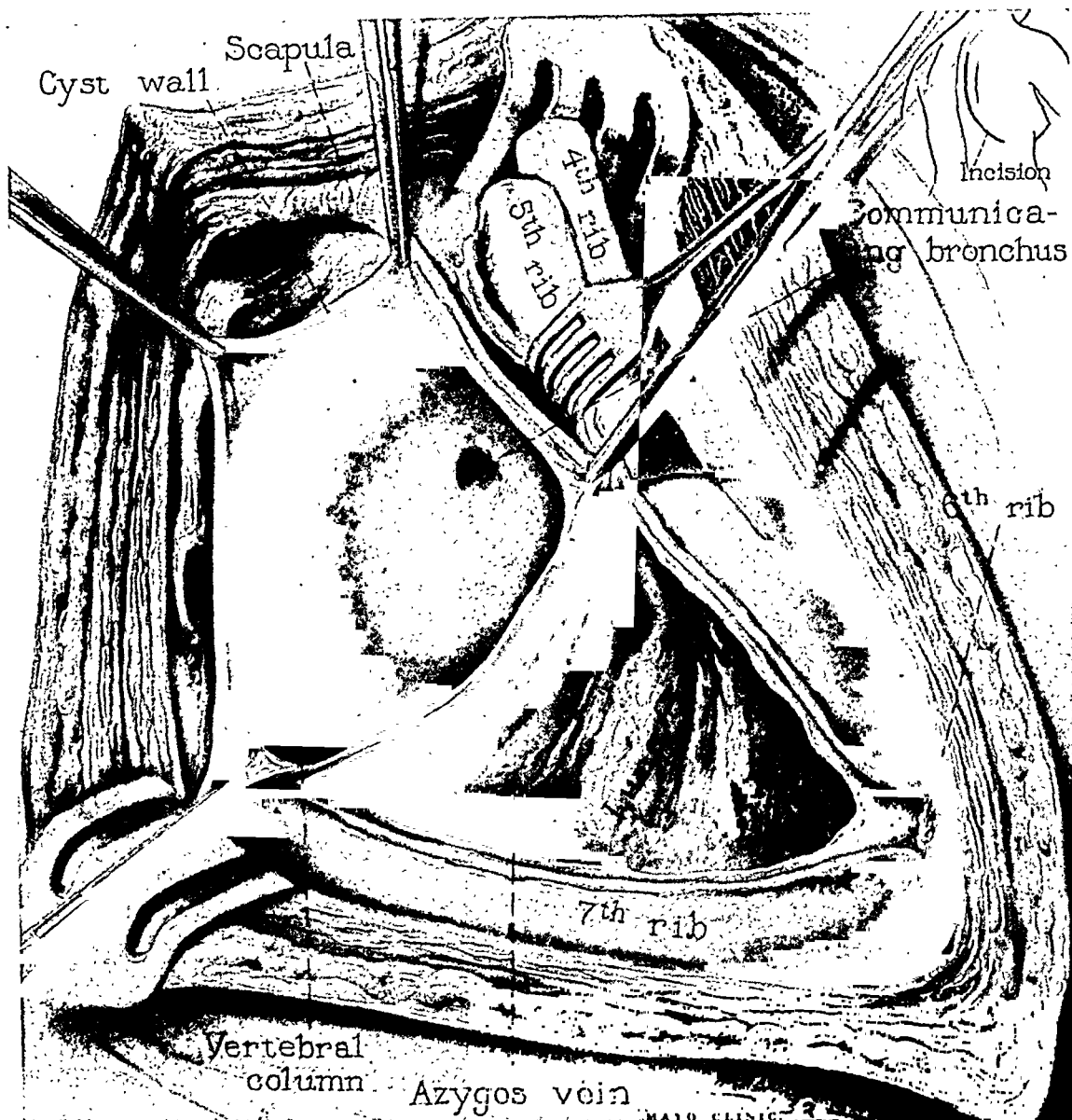


FIG. 4.—Posterior mediastinotomy, with resection of posterior two-thirds of sixth rib, and section of fourth and fifth ribs. Transpleural exposure of cystic azygos lobe in the posterior mediastinum, after it had been dissected free from its attachment to the adjacent lung. The mucoid material of the cyst had been removed, disclosing the large, communicating bronchus in the base of the cyst. The azygos major vein separates the cyst from the adjacent lung.

base, in the middle portion of the cyst. This undoubtedly was the bronchus, through which the material was removed by bronchoscopical examination, and through which the expectorated, pus-like material was flowing. The posterior and left walls of the cyst were fused to the hilum of the lung, and the posterior portion was adherent to the vertebræ as well as to the left pleura and aortic wall. The azygos major vein was markedly dilated, and was incorporated in the wall of the base of the cyst. About two-thirds of the wall of the cyst were excised. The cavity of the cyst was lined with epithelium, and its walls were very vascular and contained remnants of pulmonary

tissue. On examination in the laboratory, the walls of the cyst were found to contain cartilage and all types of pulmonary tissue, indicating that this undoubtedly was a congenital cyst of the lung. The bronchial fistula was closed by suture, and the remaining portion of the sac was sutured over the bronchial fistula, after the lining of the sac had been obliterated. It was necessary to repair by suture three areas in the upper, median portion of the right lung, where the tumor had infiltrated into the pulmonary tissue. The right pleural cavity was completely closed without drainage.

Pathological examination of the wall of the cyst disclosed that it was lined with ciliated, columnar epithelium, and that there were other bronchogenic structures in the thickened portion of the wall, at the base of the cyst.

The patient withstood the operation very well. There was a moderate reaction. Temperature was 101° F. and the pulse-rate was 110 on the second day. The pulse-rate gradually dropped to normal on the sixth day, but on this day there was gradual increase in temperature and pulse-rate. Examination of the thorax revealed a pleural

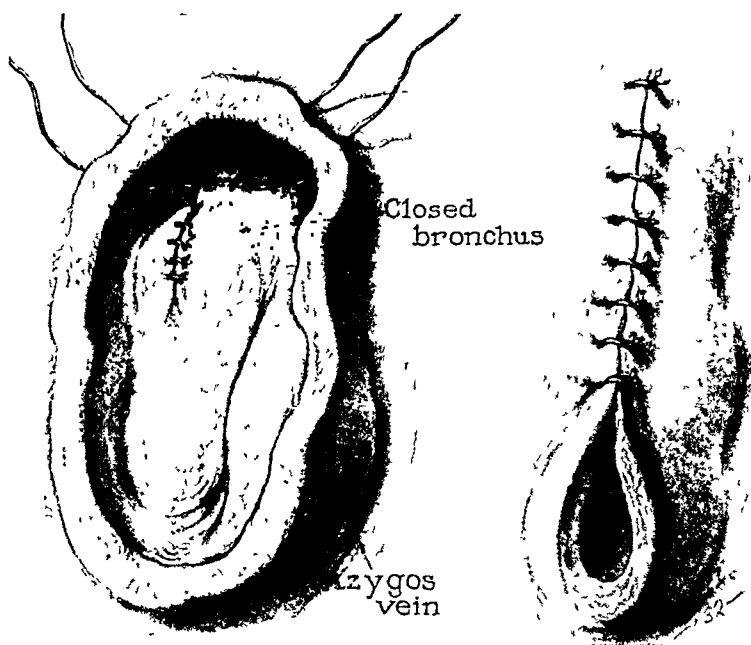


FIG. 5.—Method of closure of a large communicating bronchus with mattress and interrupted sutures of chromic catgut, and also the method of obliteration of the base of the cyst after the ciliated epithelial lining had been completely removed. The lower end of the communicating aperture is left open for drainage.

effusion. About 1,000 cubic centimetres of bloody fluid were removed on one occasion, and found negative to culture. No further aspirations were necessary. The lung remained fully expanded after the pleurocentesis. (Figs. 6 and 7.) The wound healed by primary union. The patient was dismissed from the hospital on the thirty-fourth day, and from my care on the thirty-eighth day after operation.

Comment.—This case is of clinical and surgical interest because of the infrequency of occurrence of single congenital cysts of the lung which do not present symptoms until middle life. The onset of symptoms following a respiratory infection indicated an inflammatory type of lesion, and the persistence of symptoms of infection after the onset indicated inadequate drainage of the cyst. Bronchoscopical examination and aspiration were of little value because of the inaccessibility and tortuous course of the com-

municating bronchus. None of the lipiodol injected into this bronchus reached the cavity of the cyst because, although 300 cubic centimetres of pus-like material were removed by aspiration, the cyst was only partially drained. The cyst was easily accessible through the posterior mediastinal approach; it was markedly distended from the enormous pressure of the contained mucoid material. It had partially ruptured into the adjacent lung in several places. Adhesions between the cyst and this portion of the lung were so firm, and the cyst had penetrated into the substance of the lung so deeply, that it was opened in the course of dissection from the lung. The cyst was so tense with the mucoid, pus-like material, that the right pleural cavity was partially contaminated with its content. This was washed out

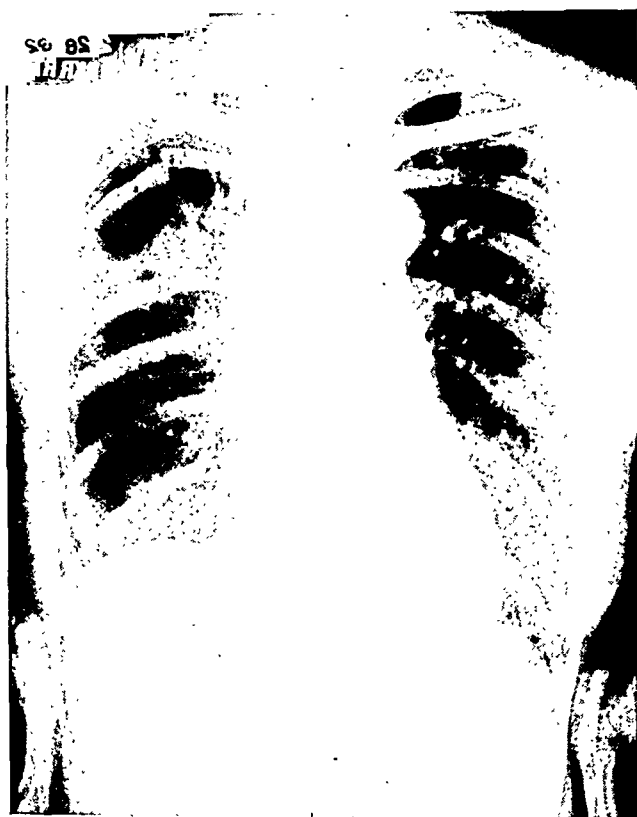


FIG. 6.



FIG. 7.

FIG. 6.—Roentgenogram on dismissal, thirty-four days after operation; the lung is fully expanded.

FIG. 7.—Appearance of the patient, thirty-four days after operation, illustrating the postero-lateral paracapsular incision of posterior mediastinotomy. The wound is entirely healed. Function of the arm was good.

with physiological sodium chloride solution, and there was no resulting infection of the pleural cavity.

The most important surgical problems were removal of the cyst with minimal injury to the adjacent lung, and treatment of the bronchial fistula and base of the cyst. The base of the cyst was firmly adherent to the vertebra and aorta posteriorly, and the inferior portion of the cyst communicated with and was incorporated into the lung at the hilum. The large dilated azygos major vein passed between the cyst and the hilum of the lung, and was fused with the wall of the cyst beneath a pleural fold. There were many large vessels in the base of the cyst, which were ligated with mattress sutures.

After the communicating bronchus had been closed, and the greater portion of the cyst had been removed, the lining was removed from the remaining base of the cyst, and the walls were approximated so as completely to obliterate the remaining space, and to aid in sealing off of the bronchus. This proved to be satisfactorily accomplished, for there was no pneumothorax after operation, and although there was considerable pleural irritation, as evidenced by the extensive, bloody, pleural effusion, only one aspiration was necessary, after which the lung remained fully expanded. Complete closure of the thorax, without drainage, contributed a great deal toward absence of serious immediate or delayed post-operative complications, and to rapid, complete recovery.

DISCUSSION.—DR. HOWARD LILIENTHAL (New York City) said as to the approach used by Doctor Harrington that it is a modification of the one which Doctor Lilienthal had devised himself, modeled on the approach of Enderlen, except that Enderlen used to remove a big flap of ribs and made a truly gigantic, troublesome operation on the chest-wall. Doctor Harrington very rarely even divided a rib. He went in between the ribs and it is astonishing to see how extensive the exposure can, in this manner, be made. One can work in the chest with both hands and see exactly what he is doing.

Another point to make is this: That if a rib has been excised—a long piece of rib—it is not always easy to close the pleura after the operation. If one has made a long intercostal incision and has supplemented it by the division of ribs, usually posteriorly, then when it comes time to close the wound by pericostal sutures, one can put the ribs closer than they were in the normal chest; besides, the pleura can be lifted up between the ribs and its edges everted, the ribs crowding the surfaces together.

The author has mentioned malignant degeneration of some of these tumors. Serious attention should be called to the fact that this can happen and that patients with mediastinal tumors—any tumor of the chest, as far as that goes—ought to be operated upon. He had had great trouble in gaining consent in a good many of his cases, until the patient has been suffering from subjective distress of considerable degree. Valuable time has thus been lost. Certainly if one is going to do anything with a tumor which is malignant it must be early, and if you would do something to a tumor which will undoubtedly make trouble, either because of its size or its malignancy, the sooner that tumor is tackled, the safer will be the operation. Some of those cases that Doctor Harrington treated radically are little short of miraculous. I might have been tempted to marsupialize one or two of these. I have succeeded by a comparatively minor operation in doing this and have had the patient remain well for many years without recurrence.

One can find out whether a case is malignant or not by performing an exploratory operation, and one will, in rare cases, perhaps, be astonished to find that a patient whose case seemed hopeless will get well.

THE CANCER PROBLEM IN THE GENERAL HOSPITAL

BY HAROLD L. FOSS, M.D.

OF DANVILLE, PA.

THE modern surgeon is finding the treatment of malignant neoplastic disease one of his most important and most difficult problems. Contending with an extraordinary surgical condition, meeting unsurmountable obstacles at every step and confronting disheartening results, he finds that, although methods of diagnosis and treatment have improved tremendously, there is still an appalling number of patients suffering from the disease in a stage so advanced that the outlook is completely and thoroughly hopeless. The rapid increase in its incidence, the invariable progressiveness of its course, and, with few exceptions, the ultimate fatal termination combined with absolute failure to discover its cause, render cancer not only the most important, but the most discouraging, of the innumerable problems with which medical science is beset.

In the hospital with which I am connected (Geisinger Memorial) the surgical staff has been greatly impressed with the ever-increasing number of cancer patients admitted to its service, with the advanced nature of the process by the time the patients reach us and, in the majority of instances, with the futility of our treatment. A large number of our beds are occupied by patients suffering from cancer, while much of our time is devoted to the examination of these patients or in apprising anxious relatives of the unpromising outlook. Furthermore, long operating lists are often largely made up of procedures performed in an attempt to cure or, at least, to alleviate the ravages of malignant disease. Such a state of affairs is to be expected in institutions devoted exclusively to the handling of cancer, but the ever-increasing magnitude of the problem must be obvious to all those connected with our general hospitals.

In this connection the relative incidence of cancer to other forms of disease among the general admissions in some of our larger hospitals is a matter of interest. At Bellevue, with 63,000 annual admissions, 1.6 per cent. of the patients have cancer. At the Massachusetts General, with 7,436 admissions, 7.4 per cent. of the patients suffer from malignant disease; at the Pennsylvania Hospital, 2.01 per cent.; at the Henry Ford, 3.1 per cent.; at the Barnes, 4.9 per cent.; at the Jefferson, 4.04 per cent. I was, therefore, led to review our own records with the object of determining the ratio of cancer to surgical admissions in general especially in rural United States; what fluctuations this ratio has shown; what types of tumors were represented; what organs affected; and what progress, if any, is being made in coping with the situation. It seemed to me that such a study might reveal

certain facts, representing possibly the relative incidence of the various pathological types more accurately than a similar study based upon the records of a large urban hospital, noted for its study of special forms of human affliction.

Although it is situated in a small community, the hospital with which I am associated is something of a medical centre for a large rural section, drawing its patients last year from over 400 towns and cities; hence, its patients represent a fairly typical cross-section of those seeking hospitalization.

During the past fifteen years there were admitted to my service 19,707 surgical house patients and of these 7.5 per cent. suffered from some form of malignant disease. When the entire series of 1,478 cases of malignant tumors was studied, it was found that, in the order of frequency of occurrence, the parts affected were as follows:

Breast	190	Penis	7
Stomach	180	Vaginal wall	6
Cervix	159	Larynx	6
Ovary	77	Spinal cord	6
Rectum	72	Pleura	5
Uterus	63	Maxilla	5
Pancreas	63	Scalp	4
Brain	56	Bile duct	4
Face	53	Testicle	4
Prostate	51	Rib	4
Bladder	43	Ileum	3
Liver	40	Ilium	3
Sigmoid	36	Sacrum	3
Colon	36	Tonsils	3
Lip	32	Antrum	3
Œsophagus	23	Orbit	3
General abdominal	22	Parotid gland	3
Skin other than face	28	Abdominal wall	2
Mouth	19	Chest wall	2
Neck	17	Tibia	2
Thyroid	16	Rectovaginal septum	1
Mandible	15	Thymus	1
Kidney	13	Optic tract	1
Tongue	12	Retropharyngeal	1
Mediastinum	11	Spleen	1
Vulva ..	10	Jejunum	1
Lung	10	Perineum ..	1
Retroperitoneal	9	Humerus	1
Femur	8	Peritoneum	1
Cæcum	8	Omentum	1
Gall-bladder	8	Eyeball	1
Rectosigmoid	8	Multiple melanoma	1

The neoplasms, according to pathological classification, occurred in the following order of frequency:

CANCER PROBLEMS IN THE GENERAL HOSPITAL

Carcinoma	1,158	Endothelioma	13
Epithelioma	149	Hypernephroma	7
Sarcoma	79	Mixed tumor parotid gland	2
Brain and cord tumors (gliomas, etc.)	62	Miscellaneous	9

In view of the widespread propaganda for the early recognition and treatment of cancer and in view of the enormous amount of information on the subject imparted to the laymen, all of which has tended to make the human race cancer-conscious to a degree heretofore hardly conceived of, I was interested in determining what results were being obtained as reflected in the elapsed time between the onset of symptoms and admission to the hospital. This factor is enlightening; yet in the face of the great educational effort that has been put forth the result is neither highly gratifying to the profession nor especially encouraging to those groups and agencies who are devoting their lives to this exceedingly important phase of human welfare.

Each year, in this country, over 125,000 die from cancer, and while it is well known that far more can be accomplished now than was possible a few years ago, nothing approaching adequate treatment has been provided for all these patients, a fact that applies particularly to those living in the rural sections. While in a few centres patients are scientifically handled, thousands are going untreated, or very inadequately treated, largely due to the amazing lack of facilities connected with the only source of relief to which the cancer sufferer has recourse—the average modern hospital.

For example, in Pennsylvania, an enlightened state, with the oldest medical school and the oldest hospital in America, in a state in which the death rate for cancer has almost doubled in twenty years, in which the deaths from cancer last year totalled over 9,000, and in which the number of living cancer sufferers is estimated at about 100,000, from a questionnaire sent to the superintendents of thirty-nine Pennsylvania institutions of over 100-bed capacity situated outside of the cities of Philadelphia and Pittsburgh, I find that only 46 per cent. have radium, that less than 50 per cent. have deep-therapy apparatus, and that only 30 per cent. have any sort of a tumor clinic. In Pennsylvania, 70 per cent. of the cancer deaths occur in people who have not been in a hospital, while 15 per cent. of the abdominal cases, according to Appel,¹ have never had the advantages of an X-ray examination.

In an attempt to determine the degree of adequacy of treatment afforded the cancer sufferer in our rural sections, the annoying, but informing, questionnaire was employed, a study being made of the entire state of Pennsylvania, exclusive of the cities of Philadelphia and Pittsburgh. Answers were received from forty-seven county medical society secretaries. A summary showed that in 64 per cent. of the counties no one trained in the use of deep X-ray therapy was available and that in 42 per cent. there was no one skilled in the use of, or possessing, a supply of radium. About one-third reported that patients were inadequately treated; although nearly all

stated that patients were coming for examination much earlier than formerly. Blame for any delay was placed about equally upon the patient and the family physician. Patients especially lacking adequate care were reported as those in the gastro-intestinal group and those in the need of radium and X-ray irradiation.

Similar data were furnished by 170 surgeons scattered throughout the state, outside of the two largest cities. Of this group, 17 per cent. reported possessing a limited supply of radium, although 59 per cent. reported having it available in one form or another. Twenty-seven per cent. reported that deep X-ray therapy was not available in their respective towns. One-third stated that, in their regions, treatment was quite inadequate; yet over 90 per cent. stated that patients were reporting much more promptly than heretofore.

The greatest needs at present were reported as being:

- (1) More perfect coöperation between the family physician and the man trained in cancer therapy.
- (2) More men skilled in the diagnosis and treatment of neoplastic disease.
- (3) Larger supplies of radium and more deep X-ray equipment, with men competent to apply these agencies.
- (4) Tumor clinics to which the practitioner can refer his patients with some assurance that they will be properly handled.

Patients most in need of more adequate care were reported as being those suffering from carcinoma of the cervix, of the breast, and of the gastro-intestinal tract.

This information, which may be considered fairly accurate, casts considerable light on conditions in rural Pennsylvania, and may be taken as indicative of conditions throughout rural United States. That much must yet be done before anything like sufficient care is provided these patients who suffer from a condition which, next to heart disease, is accounting for more deaths in the United States than any other affliction, is perfectly apparent. While there is an obvious need for more irradiation facilities, it must be emphasized that mere acquisition of the physical equipment is, perhaps, worse than useless, unless it is placed in the hands of those who have received the proper technical training in its application.

Our large city hospitals are well equipped to care for cancer patients. Indeed, certain hospitals are devoted exclusively to their care. However, the institutions in the smaller cities and towns admit the unfortunate carcinoma patient along with other general cases, tolerating them, viewing them with misgiving and a sense of fatalism, and accomplishing little or nothing, chiefly because of the lack of diagnostic and other facilities and because of a paucity of men adequately trained in cancer therapeutics.

The death rate from cancer in the United States per 100,000 of population has shown an increase of from sixty-three in 1900 to ninety-six in 1929,

CANCER PROBLEMS IN THE GENERAL HOSPITAL

an increase of 52 per cent. In 1900, cancer ranked sixth as a principal cause of death in the United States; in 1930, second. There has been a marked increase in Albany; Atlantic City; Lincoln, Nebraska; Newport, Rhode Island; Portland, Oregon; Charleston, South Carolina; and Topeka, Kansas; yet, in contrast, a pronounced decrease, for which there is no adequate explanation, in Canton, Ohio; Erie, Pennsylvania; Kansas City, Missouri; Springfield, Illinois; Trenton, New Jersey; Tampa, Florida; and Utica, New York. (Hoffman.²)

In England and Wales, from which countries we have a very careful analysis of carcinoma mortality and the results of which are in close conformity with those secured from our American records, it has recently been shown that while there has been a pronounced increase in the incidence of carcinoma of the mouth, œsophagus, stomach, gall-bladder, rectum, breast, lungs, pancreas, bladder, and prostate, there has, at the same time, been a corresponding decrease in the incidence of carcinoma of the lip, tongue, jaw, liver, penis, and uterus. To what extent the variations are due to faulty statistical returns, about which there always may be some justifiable skepticism, or to local causative factors, habits, diets, occupations, and other environmental factors, is difficult to determine.

A recent development in the modern hospital is the tumor clinic, to which patients with malignant disease are admitted and wherein they are given special attention as to diagnosis and plan of therapy by a group of men who meet periodically for the sole purpose of furnishing the best modern medical science can provide. Such clinics are, however, to be found only in the larger centres, and probably do not reach more than 25 per cent. of the great army of patients stricken annually with cancer. The other 75 per cent. turn to our small general hospitals, which, in many instances, are far less adequately equipped than those of "up state" Pennsylvania, with the only results that can be expected where no form of treatment, other than certain inadequate surgery, is provided. While it is true that there are in the United States over 1,500 approved hospitals; yet less than one-third—to be exact, 516—have deep X-ray therapy equipment; less than 400 possess any radium, while but forty-four of the 1,579 have a supply exceeding 300 milligrams. New York, as would be expected, has the largest amount—approximately 24,000 milligrams—and Pennsylvania the next, with 10,386 milligrams. In a recent survey, yet uncompleted, made by the Bureau of Mines, it was found that seven states had no radium whatever in their hospitals and that in three states no radium whatsoever is owned. In our cities, especially those with cancer institutions and research laboratories, the supply is liberal—seventeen such institutions each own 1,000 milligrams or more. Of the forty diagnostic clinics especially concerned with the cancer problem the majority are in Massachusetts and New York City. We read of the recent additional supplies of radium furnished certain centres; the five grams recently acquired by the State Institute for Study of Malignant Diseases of New York; of the two grams added to the supply of the Jeannes Hospital in Philadelphia; of

the additional four grams secured by the Department of Hospitals of the City of New York, *etc.*, but these added facilities are of no aid to the horde of sufferers in the rural sections.

A phase of the question of the treatment of malignant disease often accounting for the physician's failure to seek adequate care for his patient is a frequent lack of unanimity as to the best procedure, even when the patient has come before a group of men of the highest training and broadest experience. Attendance at a tumor conference conducted by the member of the staff of some of our hospitals exclusively devoted to the treatment of malignant tumors will quickly reveal that such a lack regularly exists. That most diametrically opposed views are held by men of equally comprehensive experience is constantly revealed in the writings of our colleagues. Within the year two distinguished members of this association have made valuable contributions to the subject of carcinoma of the breast, one holding that irradiation is completely useless as an adjunct in the treatment of this affliction; the other, with equally convincing evidence to support his conclusions, that irradiation is of the utmost value and that only the patient who has received both pre-operative and post-operative irradiation has been afforded the best that modern treatment affords. Recently I listened to a vigorous argument between two men of international reputation on the question of treatment of primary melanoma. One strongly advocated irradiation; the other, only operation. While the majority hold that irradiation is an incomparably valuable aid, a few investigators have advanced the hypothesis that it is accounting for an increasing incidence of metastasis and should be used with much greater caution—perhaps, in certain incidences, not at all. The overwhelming difficulties with which we are surrounded in handling these complex problems render differences of opinion not unexpected, but when experts disagree, then it is no wonder that the practitioner to whom is entrusted the preliminary care of probably 90 per cent. of the patients who are stricken with cancer, with the all too meagre laboratory and therapeutic facilities at his disposal and thoroughly disheartened by past experiences, literally throws up his hands when approached by the patient, or, as a sop to the patient or the harassed relatives, resorts to some form of thoroughly inadequate, often meddlesome, and usually completely futile treatment. As Cox³ has stated: "The average physician lives in the average community. He sends his patients to the average hospital which lacks facilities and equipment. The results are necessarily discouraging. The experiences encountered offer little to the average doctor to build a faith in the possible control of cancer and the results in the rural sections are the same, practically, as they were twenty-five years ago."

If our modern civilization lacks one outstanding need, it is for more adequate provision for the cancer sufferer—not so much in the cities, for there the deficiency is not apparent, but throughout the rural sections, wherein a countless number of these unfortunate humans are the victims of unnecessary and immeasurable suffering. Such a state of affairs will continue to exist,

CANCER PROBLEMS IN THE GENERAL HOSPITAL

probably increase in magnitude, until a sufficient number of centres adequately equipped with laboratory, surgical, and radiotherapeutic facilities to which every cancer patient may have ready access is established.

And so cancer is the greatest public health problem with which we are faced and is one, so far as its treatment is concerned, which the surgeon especially is expected to solve. The most important phase of the question, next to determining the chief etiological factor, is that of the treatment of the rural patients who constitute, by far, the largest group of those afflicted. Whether the solution will depend on the establishment of State- or federal-directed cancer centres, a trend toward which the profession is largely opposed, or to the establishment of adequately staffed and equipped tumor clinics in every hospital in the land, or to some other solution, the responsibility will continue to rest with the surgeon. The next decade should and, I trust, will be chiefly remembered for the profession's successful and adequate handling of the problem of the proper care of the cancer sufferer not only in the city but in the great rural sections of the United States in which the majority of these unfortunate patients are to be found.

BIBLIOGRAPHY

- ¹ Appel, Theodore B.: The Cancer Situation in Pennsylvania. *Pennsylvania Med. Jour.*, vol. xxxii, December, 1928.
- ² Hoffman, Frederick L.: *The Spectator*, June 18, 1931.
- ³ Cox, J. W.: *Bulletin American Society for Control of Cancer*, vol. xiii, No. 5.

TEMPORARY BILATERAL ABDUCTOR PARALYSIS WITHOUT NERVE INJURY AND TETANY FOLLOWING THYROIDECTOMY

BY HERBERT A. BRUCE, M.D., F.R.C.S. ENG.

OF TORONTO, CANADA

IT WOULD be difficult to conceive a more distressing event following an operation than bilateral abductor paralysis with its accompanying dyspnoea, alarming alike to the patient and only slightly less so to the surgeon, who has the responsibility of devising a speedy measure of relief.

The case that I am about to report is the first that I have had in an experience of thirty years of thyroid surgery, enabling me to appreciate the force of Crile's apt dictum that unilateral abductor paralysis is unfortunate, but that bilateral abductor paralysis is a tragedy.

In Billroth's clinic, a little more than half a century ago, post-operative tetany and injuries to the recurrent laryngeal nerve were very common. In thirty-one cases he reported 30 per cent. of nerve injuries. Von Mikulicz,¹ who was his pupil, observed the frequent sequelæ of recurrent nerve injury, of tetany and cachexia strumi priva, considered at the time to be largely due to rough handling of the tissues and injury of the thyroid nerves, and also that the unilateral operation did not relieve the compression of the trachea when present, which condition necessitated the removal of the opposite lobe, and to obviate these unpleasant complications he devised his operation of bilateral resection—the so-called melon schnitt lobectomy, leaving only that portion of each lobe which is in relation with the posterior capsule and the inferior thyroid artery. He ligated the superior thyroid arteries and the superficial branches of the inferior thyroid arteries, freed the anterior and lateral surfaces of the trachea, and split the lobe longitudinally, removing the melon-shaped section and leaving that portion of the gland and its capsule in the groove between the trachea and the œsophagus, and avoided dissecting too far posteriorly for fear of injuring the recurrent nerve. This bilateral partial resection marked a decided advance in technic and eliminated the complications which had previously been too common. With unessential modification this procedure has been universally adopted.

In my case, however, there was no injury to the nerves, as was shown by the fact that the patient could speak and breathe normally following the operation. She was forty-three years of age, and thyroidectomy was performed for a very large adenomatous goitre involving both lobes about equally, which had caused frequent attacks of dyspnoea and loss of voice. Both lobes were removed under novocaine infiltration supplemented by gas and oxygen, there being no exceptional difficulty met with at the operation. Care was taken to leave a layer of thyroid substance in front of the posterior capsule and on the inner side. After the removal of each lobe the anterior capsule was stitched together. Her voice was normal and there was no disturbance in breathing until thirty-six hours after the operation when it became noisy and labored, and an examination by Dr. Geoffrey Boyd showed both cords fixed in a position of adduction. Oxygen and

TEMPORARY LARYNGEAL PARALYSIS AFTER THYROIDECTOMY

steam inhalations were used, but the dyspnoea increased with great stridor and cyanosis until twenty-four hours later it became alarming and a tracheotomy had to be performed. This gave immediate relief but the next day acute tetany developed. For this we gave calcium intravenously and parathyroid extract, but got no relief until we secured Collip's "Parathormone," and in twenty minutes after an injection of one cubic centimetre her symptoms disappeared. This was repeated daily for one week. The tracheotomy tube was left in for two weeks, when a laryngoscopic examination showed the cords to be moving slightly, and in six weeks' time she began to speak, and at the end of three months she had completely recovered her voice and seemed in normal health.

Wood² records five cases among 425 thyroidectomies at the Bristol General Hospital during the last seventeen years. Each case was operated on by a different surgeon.

Greene,³ reports fifteen cases of temporary paralysis following thyroidectomy and states that it is not infrequently met with, and may occur during the operation from pinching the nerve or stretching it, or from pressure by the finger in controlling bleeding. If the nerve is not cut, the function will be restored usually in a few weeks' time.

Rankin⁴ reports two cases of temporary abductor paralysis in 4,249 thyroidectomies at The Mayo Clinic.

Fowler and Hanson⁵ found in 200 cadavers examined that the posterior capsule of the thyroid gland left the gland at the postero-lateral portion of its lobe and passed directly backwards to the prevertebral fascia, thus leaving the posterior surface of the thyroid lobe uncovered and in direct contact with the nerve.

Nerve paralysis following thyroidectomy may be due to any of the following:

- (1) Œdema or hæmorrhage about the nerves.
- (2) Pull on the nerve (when the goitre is being rolled out).
- (3) A finger behind the upper pole (Crile's view).
- (4) Traction.
- (5) Accidental ligation.

When the paralysis comes on later it may be due to inclusion in scar or malignant tissue. I believe that my case was clearly due to œdema of the tissues surrounding the nerves and compressing them.

It is a fact that the slightest direct or even indirect pressure on the recurrent nerves interferes with nerve conduction and immediately changes the voice. New, Judd and Mann⁶ studied the effect of trauma upon the laryngeal nerves and found that pinching the nerve with a hemostat at various points gave paralysis of the cord. There was complete restoration in every case in thirty to sixty days. That the laryngeal nerves in these cases were not injured was proven by tests of the cord immediately following the operation, and also by the fact that the complication cleared up in the course of six weeks.

It has been urged that in all cases where a thyroidectomy is contemplated, the vocal cords should be examined before operation as a routine, as it has been found in an examination of a large number of persons that about 1 per cent. have unilateral paralysis of the vocal cord. It is advisable that tracheotomy should be done early following thyroidectomy if abductor paralysis develops, because it is not nearly so hazardous a procedure as late tracheotomy, as in the latter case the heart is embarrassed by long labor against congestion.

Although we believe there was no injury to the nerves during operation, and that they suffered subsequently from pressure due to inflammatory

œdema, it might be of interest to recapitulate some points in the procedure which most surgeons now regard as important for the protection of the nerves. After the normal skin incision:

(1) A vertical incision through the fascia from the level of the larynx down to the sternum.

(2) Separation of the muscles will now expose the capsule of the gland.

(3) Division of the capsule on the tracheal side between forceps, working downwards and outwards, taking care to leave a thick covering of thyroid tissue to protect the trachea and larynx. When the posterior capsule is reached, leave a sufficient covering of thyroid tissue to protect the nerve. The posterior part of the thyroid should not be palpated.

(4) After removal of one lobe get the patient to talk.

(5) Perfect hemostasis must be secured. Let the patient strain or cough to see if there are any open vessels. Catch individual bleeding points without grabbing a large amount of tissue.

(6) Avoid rough sponging and pulling.

Now a word about tetany. The parathyroids lie in pairs near the distribution of the inferior thyroid arteries, and are supplied by these vessels. Tetany may be due to crushing by artery forceps or by tying off this blood supply. Halsted, to avoid this, advised ligaturing the branches inside the capsule of the thyroid (which was done in my case). The occurrence of tetany may be also explained as being due to irregular distribution of the parathyroids. Crile⁷ reports five cases of acute post-operative tetany treated by intravenous injection of one cubic-centimetre of Collip's "Parathormone," three doses of two cubic centimetres resulting in complete recovery.

A chronic form of tetany, due to destruction of the parathyroids by scar tissue, may occur, in which case there is a long interval after operation before tetany sets in. The onset may be from twelve hours to four months. There are two stages in the symptoms. The most acute phase, with spasms of the limbs, is obvious. The elbows and wrists are flexed and the hand pronated. The thumb is opposed to the palm, the knuckle-joints are flexed and the other finger-joints are extended, the feet and toes being in plantar flexion. Severe pain is complained of. In the alternative phase there is no pain.

BIBLIOGRAPHY

- ¹ Von Mikulicz, J.: *Centralblatt für Chir.*, No. 15, p. 889, December 19, 1885; *Wien Med. Woch.*, vol. xxxvi, pp. 1, 40, 70, 97, 1886.
- ² Wood, Duncan: *Bristol Medico-Chir. Jour.*, vol. xlviii, p. 205, Autumn, 1931.
- ³ Greene, E. I.: *Temporary Paralysis of the Recurrent Laryngeal Nerves Following Thyroidectomy*. *Surg., Gynec., and Obst.*, vol. lii, p. 1153.
- ⁴ Rankin, F. W.: *ANNALS OF SURGERY*, vol. xc, p. 948, 1929.
- ⁵ Fowler, C. H., and Hanson, W. L.: *Surg., Gynec., and Obst.*, vol. xlix, p. 59, 1929.
- ⁶ Judd, E. S., New, G. B., and Mann, F. C.: *Effect of Trauma upon Laryngeal Nerves*. *ANNALS OF SURGERY*, vol. lxxvii, p. 257, 1918.
- ⁷ Crile, G. W.: *The Prevention of Abductor Paralysis in Thyroidectomy*. *Surg., Gynec., and Obst.*, vol. xlix, No. 4, p. 538.

RESULTS OBTAINED IN THE TREATMENT OF RAYNAUD'S DISEASE BY SYMPATHETIC NEURECTOMY AND IN THROMBO-ANGIITIS OBLITERANS BY DESENSITIZATION OF PERIPHERAL SENSORY NERVES

BY ARTHUR W. ALLEN, M.D.

OF BOSTON, MASS.

FROM THE PERIPHERAL VASCULAR CLINIC OF THE MASSACHUSETTS GENERAL HOSPITAL

DURING the three-and-one-half-year period from December 1, 1928, to May 1, 1932, the peripheral vascular diseases at the Massachusetts General Hospital have been cared for under a special assignment. Four hundred and thirty-five of these cases, exclusive of varicose-vein patients, have applied to us for treatment. Of these, eighty-eight have been classified as thrombo-angiitis obliterans and eighty-eight as vasomotor imbalance. The remaining number fall into the groups of arteriosclerotic obliterative disease, senile or diabetic, and diabetes with infection. All of these patients have had the benefit of the general management of peripheral vascular lesions used in our clinic and previously reported. Two hundred and twenty-five of the cases applying for treatment have been sufficiently mild in character for ambulatory care and these have been treated in the out-patient department. Two hundred and ten required and accepted hospitalization. Inasmuch as we have been particularly interested in sympathetic neurectomy in severe and advanced cases of vasomotor imbalance and in desensitization of peripheral sensory nerves in thrombo-angiitis obliterans with painful lesions, it seems in order to report our results on patients so treated.

Vasomotor imbalance.—These cases fall into two main groups, those with apparently primary vasomotor disturbances and range in severity from mild multiple phase-color reactions with periods of normalcy to those who develop gangrene of the finger-tips or toes. In the other group we have conditions complicating the picture in such a way as to suggest a secondary vasomotor spasm. These may have scleroderma or arthritis or be secondary to peripheral injury or infection.

Although there have been some cases of poliomyelitis with secondary vasomotor spasm operated upon by Dr. W. J. Mixter, these will not be included in this report. All of the cases subjected to sympathetic neurectomy are first blocked with novocaine to determine their vasomotor response. In all of these cases the rise in peripheral surface temperature has been above 15° F. Very rarely has a patient without severe, advanced disease been operated upon. Nearly all had open lesions or were incapacitated from the disease. Various members of the surgical staff associated with the peripheral vascular and neuro-surgical clinics have performed the operations. All of the cases reported here were operated upon at least twelve months ago. All recur-

rences that we have seen have come within a shorter period of time, usually four to eight months. The lumbar sympathectomies have usually been bilateral in one operation. A few of the cervicodorsal operations have been bilateral in one stage, but usually these have been done one side at a time. There has been only one post-operative fatality in the entire group, and was reported before this society in 1930. There have been few post-operative complications, the most annoying that of a transient neuritis following the cervicodorsal operations.

Vasomotor Diseases—Primary—(Raynaud's).—In this group, eleven patients have been subjected to twenty-three sympathetic neurectomies, as follows:

	<i>Patients</i>	<i>Vasomotor influence returned—failures:</i>
Quadrilateral	2	Cervicodorsal—eleven in six patients.
Bilateral cervicodorsal	4	Vasomotor influence did not return from
Bilateral lumbar	2	twelve to forty months:
Unilateral cervicodorsal	3	Cervicodorsal—four in three patients.
	—	Lumbar— eight in four patients.
	11	
	<i>Sides</i>	
Cervicodorsal	15	
Lumbar	8	
	—	
	23	

Vasomotor Disease—Secondary.—In this group, ten patients have been subjected to fourteen sympathetic neurectomies, as follows:

	<i>Patients</i>	<i>Cervicodorsal Sides</i>	<i>Lumbar Sides</i>	<i>Return of Vasomotor Spasm</i>	<i>No Return of Vasomotor Control</i>
Scleroderma	3	3	0	1	2
Arthritis	3	4	0	0	4
Post-traumatic pain and swelling...	1	0	2	0	2
Tuberculicide of feet	1	0	2	0	2
Fibrosis of fingers following infection	1	2	0	2	0
Spina bifida occulta	1	0	1	0	1
	—	—	—	—	—
Totals	10	9	5	3	11

Combined table of vasomotor disorders operated upon:

	<i>Patients</i>	<i>Cervicodorsal Sides</i>	<i>Recurrences</i>	<i>Relieved</i>
Primary disease	11	15	11	4
		Lumbar Sides		
		8	0	8
		Cervicodorsal Sides		
Secondary disease	10	9	3	6
		Lumbar Sides		
		5	0	5
	—	—	—	—
Totals	21	37	14	23

It is interesting to note that none of the lumbar ganglionectomies has shown a return of vasomotor influence in the feet. In one of these sides due to anomalous distribution there was failure to completely eliminate sweating over the dorsum of the foot but this was observed immediately after the operation and the condition has remained unchanged. We believe that there are two factors that contribute to the constant results in the lower extremity. Most of these operations were done by surgeons who were more familiar with abdominal surgery and therefore were better able to expose and remove a sufficient portion of the sympathetic chain in this region. The most important factor, however, seems to be that in the lumbar region the ganglia are more widely separated and have fewer communicating rami than in the cervicodorsal region. This makes it possible to obtain a wider break in the lumbar chain.

It is to be noted that a greater number of the cervicodorsal operations were successful in the secondary vasomotor disorders than in the primary group. It seems logical at this time to suggest this fact as supporting Raynaud's original hypothesis of an abnormal central vasomotor control in these cases. Certainly there is a greater tendency on the part of nature to re-establish vasomotor function in true Raynaud's disease than in those in which the imbalance may be secondary to local peripheral irritation. All of the operations on the upper extremity were relieved of all or most of their vasomotor influence for periods of from four to ten months after operation. There are definitely more opportunities in this region to leave behind connecting rami, and to fail to remove a sufficient amount of the chain to permanently break the sympathetic influence. Some of our operations in this region, especially in our earlier cases, were purposely limited to the first and second dorsal ganglia and the communicating trunk. Strangely enough, one of our most striking results was in a severe primary vasomotor disease with gangrene in which the inferior cervical was not removed. In this case there has not been a return of vasomotor influence. All of the cases subjected to cervicodorsal neurectomy for the past year and some prior to this time have had the inferior cervical, first and second dorsal and all communicating rami and trunk removed. We hope this will offer more certain prognosis and that there will be fewer instances of return of vasomotor influence.

Thrombo-angiitis Obliterans.—Severe and advanced cases of thrombo-angiitis obliterans with open painful lesions have been admitted to the hospital for treatment under the direction of the Peripheral Vascular Clinic. All of these cases have had general routine measures in addition to special forms of therapy.

In the three-year period from December 1, 1928, to December 1, 1931, there have been thirty-six of these advanced cases in the hospital. Twenty-nine of these were treated by sensory-nerve desensitization, as advocated by Smithwick and White, of our clinic. Alcohol injection was used in all the posterior tibial nerves and in some of the smaller ones, the small nerves being crushed or cut in the others. All the nerves were seldom done at one

sitting, as it has been found that by spacing the procedure a week apart there is less disturbance to the border-line circulation. It has been necessary to take into account rather frequent anatomical variations and obtain complete comfort before proper dressings could be done and postural-change exercises carried out. Also, the maximum benefit of the usually small vasomotor element was best obtained in the completely desensitized foot. These individuals have had very little difficulty arising from lack of sensation. Great care is exercised to prevent ulceration on pressure points by suitable arch supports of sponge rubber and leather. None of this group has complained very much of paræsthesæ. The nerves have regenerated in from four to twelve months—in the later cases return of sensation has more or less accurately paralleled healing and return of function.

Twelve of the twenty-nine cases have required major amputation, due to spreading gangrene or infection. Of the remaining seventeen cases where healing and return of function have taken place, almost all have lost parts of the toes, but all are left with serviceable feet. From previous experience it is safe to prophesy that some of these favorable results are probably temporary, although many of them have had useful painless extremities from one to three years.

In a series of twenty-one cases of this same severe grade of the disease treated prior to the time of desensitization, the percentage of major amputations was more than twice as great as in the more recent group.

If palliative treatment is worth while at all in this advanced group, we believe desensitization is indicated for the relief of pain alone, and although they are time-consuming, a considerable number of useful extremities are saved.

In a few instances we have attempted to alleviate pain in this group by lumbar sympathetic neurectomy, without success. If this procedure has a place in the treatment of thrombo-angiitis obliterans, it should be used in an earlier stage of the disease and limited to those cases with a high vasomotor index.

RESULTS OF OPERATIVE TREATMENT OF CANCER OF THE BREAST

BY FRANK S. MATHEWS, M.D.
OF NEW YORK, N.Y.

It is purposed to present in this paper the results of operation on carcinoma of the breast both early and late. The surgical operation has been followed, especially in the later years, by X-ray therapy in an increasing percentage of cases. The wisdom of surgical treatment in the late cases may well be open to question, some preferring to restrict surgery to what are called "operable cases." But when surgical treatment is selected for a portion of the cases only, the statistical value of reports is impaired and it ceases to be possible to compare the series of different operators.*

Cures are spoken of for convenience, there being no time in the cancer patient's life when it may be said that recurrence is no longer a possibility.

The characteristics of the series which seem to make it worthy of presentation are:

First, it is not a selected group.

Second, the follow-up is almost complete.

Third, it is the work of an of an individual rather than a group. This has advantages and disadvantages.

Fourth, a surgical technic has been followed which is uniform throughout the period and has varied only in unimportant details.

Fifth, it is believed that the pathological reports are dependable, in nearly all cases being made by Dr. F. C. Wood and Dr. L. C. Knox, at St. Luke's Hospital.

Sixth, it illustrates a willingness to operate for amelioration of symptoms when it is not for the operator's statistical advantage.

Seventh, no group has been erected for the inclusion of patients who refuse to submit to operation. Operation has at times been postponed but no case is recalled in which operative surgery has been absolutely refused.

Two hundred and twenty-five patients have been operated on during the last nineteen years and with few exceptions at St. Luke's Hospital. Three patients have died from operation. In seven cases the clinical diagnosis has not been confirmed by microscopical examination. Two patients have died

* Lewis and Rienhoff¹ say that of their 950 cases of carcinoma, 7.6 per cent. only were dismissed without operation. Handley² reports seventy-seven operations of which twenty-nine were "frankly palliative." He then computes a 45 per cent. of three- to six-year cures, including a patient who dies of pneumonia, as a non-recurrence. Unless all patients operated on contribute to the statistics, comparison with the statistics of other operators will have slight value for each surgeon will have different views as to what constitutes the "frankly palliative" group.

of carcinoma of the uterus—one of them having it at the same time as an epithelioma of the breast and the second developing a carcinoma of the uterine body from which she died five years after mastectomy without signs of local recurrence. If these patients are eliminated, 213 remain for study.* Thirteen of them, though subjected to operation, are recorded as incomplete operations, this meaning either that the mastectomy was not of the usual extent or did not macroscopically extend beyond the disease. If these were eliminated, the number of cases would be exactly 200. These thirteen very advanced cases have all died within a year and no great gain can be claimed for operation. Moreover, it is considered inadvisable to perform palliative operations if an open wound rather than a closed one is to be left for the remainder of the patient's days.

Mortality.—Halsted was wont to say that though his operation for cancer of the breast seemed extensive and time-consuming, it was accompanied by an almost negligible mortality. This has not always been confirmed in the practice of other surgeons. Mortality rates of from 1 to 12 per cent. have been reported. The three deaths constituting the 1.3 per cent. mortality in this list have been, one from pneumonia, one from delirium tremens on the third day, and one from pulmonary embolus on the twentieth day. The pathological department at St. Luke's Hospital reports a 1.6 per cent. mortality for the hospital in breast cancer. White³ reports from Roosevelt Hospital a mortality of 2.9 per cent. Lane-Clayton,⁴ from eight large British cities, reports a mortality of just under 3 per cent. among 2,006 patients. Lewis and Rienhoff¹ report a mortality of 6.4 per cent. from the service of Johns Hopkins Hospital. A short series of cases has recently been reported with a mortality of 12 per cent.⁵

One would think that, with present-day operative technic, there should be no deaths from shock or hæmorrhage, quite rarely from sepsis, and that any legitimate mortality should result from such unavoidable accidents as embolus, apoplexy, myocarditis, *etc.*

Follow-up.—The follow-up from 1913 to May 1, 1932, shows 133 patients dead, seventy-three living, five living with recurrence, two lost to follow-up after remaining well over five years. The total is 213 patients. On five others there was no follow-up. This accounts for the total carcinomas of the series (218) and gives a follow-up percentage of patients from 1913 to date of ninety-seven. Klingenstein⁶ reports a follow-up on patients of Mt. Sinai Hospital for a period of five years as 75 per cent. Lewis and Rienhoff¹ report a 78 per cent. follow-up from the Johns Hopkins Hospital.

* The material includes one male patient with carcinoma. There are two sarcomas, one in a patient who died shortly of local hæmorrhages; the other with fibrosarcoma has remained well over six years. Two patients have survived pregnancy, one of them living three years and the other five years thereafter. In neither was there a recurrence locally nor in the opposite breast. Contrary to a general impression, the pregnancy seems to have been only an incident in the course of the carcinoma. The recurrence was in the pleura in one case and in the supraclavicular glands in the other.

RESULTS OPERATIONS FOR BREAST CANCER

One occasionally sees attempts to give statistical information based on a follow-up of 50 per cent. or less. It would seem as if such statistics could be of little value for they require some form of manipulation either in the form of assumptions as to those lacking or else consider those followed as though they constituted the entire material.

Operation.—The operation is the Halsted-Meyer one with the modification of extensive skin undermining as suggested by Handley.² The skin incision has varied considerably but in the main has resembled that of Halsted. The sacrifice of skin has been moderate and efforts have been made to close the wound without skin grafting. The undermining of tissues has extended into all directions from the middle line to the margin of the latissimus dorsi muscle. The episternal notch has usually but not invariably been invaded, this depending chiefly on the location of the tumor. After making the incision and bringing the dissection in every direction down to muscle, the Meyers technic has then been invariably followed, dividing the pectorals at their insertions and then proceeding with the dissection from the apex of the axilla downward. This seems the more logical method and probably is accompanied by less bleeding. The attempt has been made to remove the tissue in one piece. Formerly supraclavicular dissection was employed in a number of cases but has been almost wholly abandoned in the belief that very little good is accomplished by it.

Accuracy of Diagnosis.—That the "clinical diagnosis of carcinoma of the breast is seldom wrong"⁷ deserves some modification. In the hands of the general practitioner the statement is far from accurate. In the later cases of carcinoma it closely approaches the truth. But in the earliest cases, those in which we are most deeply interested as surgeons, the clinical diagnosis is far from satisfactory. White³ says: "It is our confirmed observation that in the early cases it is very often impossible to make a definite diagnosis before local excision." It is because of the clinical uncertainty that resort to frozen-section diagnosis has very frequently been made. The tumor is first incised or excised for macroscopical and microscopical diagnosis. The wound is closed and the operation proceeded with. From the dissector's standpoint, it seems rather undesirable to remove the entire breast as though for a benign condition and then proceed with a radical mastectomy when the tumor is found to be cancer. The microscopical diagnosis, though not infallible, as shown by slight difference of opinion among pathologists, is many times more accurate than the clinical one. In this series, seven cases have been excluded on which radical mastectomy has been done, the clinical diagnosis of suspected malignancy not being confirmed by the pathological report. As far as the follow-up has been made on these cases, it tends to confirm the accuracy of the pathologist's decision rather than the clinical one in these seven cases.

Lymph-node Involvement.—The involvement of nodes has been recorded in almost every case. In 144 patients they were involved and in sixty-eight not. This gives a percentage of involvement of 67.3. The absence of in-

involvement is possibly our best factor in estimating a favorable prognosis. It was found that whereas 67 per cent. is the involvement for the entire group, in the cases remaining well ten years or more, twenty-three in number, only five had involvement—a percentage of 21.7. This prognostic value is not invariable when applied to the individual case, for some without involvement do conspicuously badly while some with involvement may remain local in their metastases and with or without subsequent local removals live for many years. Of forty-five patients with uninvolved glands operated on over five years ago, twenty-nine lived over five years—a percentage of 64.4.

The following is an analysis of freedom from recurrence over a five-year period in cases that had no axillary involvement as reported from three sources:

	Cases	Cures (%)
Sistrunk and McCarthy (Mayo Clinic) ^a	86	63
White (The Roosevelt Hospital) ^b	55	70
Mathews (St. Luke's Hospital).....	45	64.4

Bloodgood¹⁰ rather optimistically states: "The probability of the five-year cure when the glands are not involved varies from 70 to 95 per cent., according to the type of the cancer."

Early Deaths.—One-third of the patients in this series have died within two years of the operation. Of those operated on in the last three years—thirty-six in number—eleven are now dead or living with recurrence—30.4 per cent. Of those operated on within the last five years, sixty-two in number, twenty-five are dead or living with recurrence—40 per cent. Other surgeons call attention to this high early mortality and the propriety of operating in these more advanced cases is naturally called into question. But there are justifications for it. Of the less important is the fact that the patients have some mental relief from the knowledge that their tumor has been removed and that a sloughing sore is removed or prevented. More important is the fact that now and then a patient with what seems an unpromising condition goes on with comparative health for a considerable number of years. Three such cases in this series have lived seven to eleven years. A question of more importance is whether the lives of any considerable number of these late cases are shortened by operation. It is my personal belief that of this large group not surviving the two-year period, the length of life is neither appreciably lengthened or shortened with the exception of those who do not survive the operation.

Death from Intercurrent Disease.—In a series of 138 deaths, only nine patients are reasonably believed to have died from other diseases than cancer—a percentage of 6.5. We find reported hemiplegia, cerebral hemorrhage, cardionephritis and acute indigestion. But of these so reported it is certain that some at the time of death were suffering also from evidences of cancer. It seems, therefore, that no great error is introduced into the statistics by including these patients among those dead from carcinoma and it simplifies the statistical handling. In the preparation of this paper about a dozen cases

RESULTS OPERATIONS FOR BREAST CANCER

which we could not follow by other methods were traced at the Bureau of Vital Statistics. Of several of these, other causes of death were given than carcinoma, though all of them died within two years of operations and hence presumably of cancer. The most amusing illustration of this comes from our own hospital. A patient returned to our medical ward nine months after the carcinoma operation, was diagnosed acute pleurisy, discharged as recovered, and is reported at the Board of Health as having died two months later of pleural carcinoma. In view of the above consideration, no statistical account is taken in this series of patients dying with intercurrent disease and if five-year cures only are concerned, the error must be very slight. Of course, if the patients are followed for ten or fifteen years, the statistical error which would be introduced would increase considerably.

Bilateral Carcinoma.—This subject seems rather mystifying. Thirteen of the patients have been known to have had carcinoma of the opposite breast—a rather larger number than in other series. Lewis and Rienhoff¹ reported it in 4.7 per cent. of their cases. In our 218 cases the percentage is 6, or, if one compares them with the total number of patients with recurrence of carcinoma, it is thirteen bilaterals in 145 patients, or 9 per cent. Seven of the patients are now living. Six have no recurrence on the side of the original tumor or had none up to the time of death. In two cases, toward the end of life, carcinomatous nodules were present all over both sides of the chest.

To consider the late appearance of the second carcinoma as a metastasis, we must assume that at the time of the original operation an embolus had reached the opposite breast for the freedom from recurrence on the primary side has seemed impressive. What the embolus is doing or what is holding it in check for seven, eight or eleven years before its clinical manifestation is hard to understand. Nevertheless, we have no pathological basis for belief that any one of them showed sufficient difference in type of the two growths for the belief that the second breast was involved as a second primary carcinoma. There is no evidence of a particularly free lymphatic connection between the two mammary glands. Nevertheless, in a number of cases the nodule has appeared as a small, discreet one in mammary-gland substance without any nodules in the skin or surrounding tissues. It almost seems as if the mammary tissue might possess a special susceptibility to cancerous emboli. One patient had a recurrence after six and one-half years. The glands were not involved at the primary breast operation nor were they at the second. In two patients seen just before death, the breast, axilla and surrounding skin were filled with metastases, but the region of the primary operation was still clear.

TABLE I
RESULTS OF OPERATION

Ten-Year Cures

96 patients—23 living	23.9%
Of 23, 18 without gland involvement.	

FRANK S. MATHEWS

Five-Year Cures

153 patients—58 living	37.8%
Of 58, 29 without gland involvement.	
Or, deducting 9 incomplete operations	
144 cases—58 living	40.2%

The nine patients deducted to obtain the higher percentage of cures would none of them have been operated on by a surgeon with any idea of cure in mind. Some were operated on with local anæsthesia. One operation occupied twenty minutes and none lived over a year.

TABLE II

Five-Year Cures

	Cases	Cures (%)
Adair (surgery alone)	23	8.7
Lee and Cornell (New York Hospital).....	75	15
Klingenstein (Mt. Sinai)	57	23
Moschcowitz, <i>et al.</i> (Mt. Sinai) ¹⁵	89	34
White (Roosevelt Hospital)	157	36
Lee (Surgery and pre- and post-operative irradiation).....	41	39
Mathews (Surgery, some X-ray).....	153	37.8
	or 144	40.2
Adair (Memorial Hospital) (Primary surgery, irradiation or combinations)	197	46
Lane-Clayton (British cities)*.....	2,006	37.4

Table II presents results of operation with five-year cures as reported in several New York hospitals and in the main the percentages do not differ widely for different institutions throughout the country. This seems to indicate a fairly uniform average type of patient and that operations are performed about equally well in the different hospitals. For comparison with our own hospitals we have inserted the figures as reported to the Ministry of Health for Great Britain. "It has been obtained from the surgical practice at general hospitals of eight of the largest provincial towns in England and Wales. A large proportion of the hospitals are teaching hospitals and are representative of the best work in the country."⁴ It shows, moreover, that the operative results without radiation are about the same as in this country.

Location of Recurrences.—Under this heading the statistical method has been abandoned and replaced by impressions only, for the reason that in such a large number of cases, especially those with early terminations, the patients have drifted away and evidence as to the first appearance of metastases has been of the hear-say variety. It is extracted from the patient's friends, from the patient's physician—often not too disposed to interest himself in observing the first signs of metastases—and death certificates which have seemed notoriously unreliable as sources of information. Recurrences in the chest, pleura, mediastinum or lung have easily headed the list. Metastases in the opposite breast have already been commented upon.

* Of 420 Johns Hopkins cases, known to have died 18 per cent. lived over five years.

RESULTS OPERATIONS FOR BREAST CANCER

It is interesting to observe that though the axillary nodes are involved in 67 per cent. of the cases, yet we seem conspicuously successful in avoiding axillary metastases. This fact is given special emphasis in Lane-Claypon's statistical report from Great Britain.⁴ Most striking to me has been the observation that patients go to their grave with distant metastases, often living a considerable period with them, yet at the moment of death showing no evidence of recurrence in the scar or immediately underlying tissue. This has been especially interesting in the case of patients whose metastasis appeared first in the opposite breast and has led me to the conclusion that we are not to hope for better results by increasing the magnitude of the operation. We may extend the area of skin removal indefinitely but what is gained when the site of recurrence is in the chest? It is realized that this opinion is not generally shared and operating surgeons are known whose operations consume four to five hours, while the operations here reported have usually been completed within an hour and have not been unusually radical, the clavicular portion of the pectoralis major being preserved and the wound being closed in nearly all cases. The prolongation of operation, as in the cases where it is combined with skin grafting, would seem to lead to a higher operative mortality, as seen in the results of the Johns Hopkins Hospital series. Lewis and Rienhoff¹ devote a considerable part of their efforts to proving that the results of the operations at the Hopkins Hospital with extensive skin removal have been superior to those with closed plastics. Their argument seems to me very considerably vitiated by the fact that their surgeons have in the main abandoned it since 1925.

The spread of the disease from the original focus takes place by permeation or by embolus through lymphatics and possibly blood-vessels; and the result of operation must largely depend upon whether at the moment of operation embolus has occurred beyond the local area. Evidence derived from study of carcinoma in animals has seemed to show that many of the emboli fail to live and take hold in their new situation.

Local recurrences in the skin area or subjacent chest wall probably are next in frequency to thoracic recurrences, but these are seen mostly in the prompt recurrences both general and local in the patients dying within the first two years. When embolic transplants have already occurred at the time of operation to liver, pelvic bones, spine and brain, both surgery and radiation can be of little aid; and a hope for better things in the future must depend on the appearance of some agent to ransack the entire system for cancer-cells. Such agents—so far, gold, lead, hormones and serums—seem to have proved sadly disappointing.

Radiotherapy.—Some years ago Sir Berkeley Moynihan was widely reported as saying that he would never operate on another carcinoma of the breast. At about this time there appeared from his own country a report under the auspices of the Ministry of Health for Great Britain⁴ on the late results of operation in cancer of the breast, in which they call the "crude" survival rate for five-year cases 37.4 per cent. The net survival rate was

40.3 per cent., the latter figure being obtained after deducting those not traced and those dying from other causes than cancer. Similar figures for ten-year cures were 25.2 per cent. crude and 28.5 per cent. net. One wonders what evidence he had that matters could be improved by abandoning the surgical treatment of cancer and resorting to other methods. Probably he had been overinfluenced by discouragements in his own operative material. In the government report just mentioned, it is stated that "data are insufficient for any deduction as to the value of post-operative treatment with X-rays" and "so far as they go they can hardly be claimed as a great success for radiology."

At that time the work of Keynes¹¹ was too recent as applied to operable cases, and still is, to be used as a basis of comparison between results of radium and operative surgery. As regards the X-ray treatment of breast cancer Lee says,⁸ "The majority of cancers of the breast are relatively radio-resistant," "to deliver an efficient dose one must use interstitial irradiation." Lewis and Reinhoff,¹ in their exhaustive study of the operative results of cancer of the breast, devote a part of one sentence to "the very questionable effect of radiation." Pfahler¹² has recently reported his treatment of cancers of the breast, the number of cases being over a thousand, and has employed X-ray almost exclusively. He seems to have no hesitation in treating operable cases by this means alone; but as these cases have not been confirmed by microscopical examination and rest entirely on his clinical impression, the results are hardly to be used for statistical comparison with other series of cases. Adair¹³ says that: "As a general rule mammary cancer is not so radiosensitive nor so efficiently treated by any of the irradiation methods as cancer in certain other organs, such as carcinoma of the cervix and basal-cell epithelioma of the skin," "the occasional case of mammary carcinoma under a few treatments by irradiation completely disappears," "in general we have given up our attempts to treat this disease by external irradiation alone. We usually fail with this although there is an occasional exception. It requires heavy and prolonged irradiation by both interstitial and external methods to hold mammary cancer in abeyance to the point of a five-year cure."

To turn now to the present series of cases, it may be noted that the amount of X-ray used in the earlier cases was very small. As time has gone on a very considerable portion of the patients have received X-ray treatments—usually one treatment before leaving the hospital. After leaving the hospital, some have disappeared after a treatment or two while others have remained under observation in our radiotherapeutic department for four or five years. We are not in a position, then, to draw comparison between cases so treated and those treated by surgery alone. Of twenty-two patients now well and operated on prior to 1923, eight cases had X-ray and fourteen had none. But of the eight patients several only received their X-ray some years after operation. In two or three this was given after a small recurrence. There is little evidence, then, that the X-ray has

RESULTS OPERATIONS FOR BREAST CANCER

contributed anything substantial to these results, though it might be reasoned that the number of such ten-year cures would have been larger if all the patients had received X-ray. Only one patient has suffered any harm from radiation. She has a very distressing X-ray burn. On the other hand, it has only been my fortune to see two patients in whom there was ocular evidence of disappearance of metastases. One of these patients had a fairly encapsulated medullary carcinoma. A year later, to my surprise, there were numerous small nodules in the axillary skin. These disappeared under X-ray and the patient is now well, five years from the time of operation. The other patient had supraclavicular glandular enlargements extending as high as the tonsillar node. In three months these have strikingly subsided, to be replaced by a moderate fibrosis.

The advantages, then, of post-operative radiation with the X-ray as observed in this series are disappearance of metastases, as above, in two cases; relief of pain, at times conspicuous, even though the growth as shown by clinical or X-ray evidence is steadily extending. It is easier to keep these patients under observation for they have the feeling that they are receiving treatment as well as observation. Another considerable advantage of post-operative X-ray is that it has very largely replaced secondary operations, an advantage both to the patient and the surgeon. We feel disposed to advise, or at least present the option of post-operative radiation, even to the early operative cases, the radiation being instituted promptly after operation though having very little evidence that the five- and ten-year cures depend to any considerable extent on radiation. We think of it as an addition to surgery.

It is interesting to compare the results of surgery with little dependence on radiation with the results of treatment at the Memorial Hospital, where every form of radiation, supplanting surgery, pre- and post-operative by X-ray, radium packs, interstitial implantation of seeds, tubes and needles, has been employed. The emphasis of the institution has seemed to be on radiation methods rather than upon surgery. This is an inference drawn from the fact that in the Memorial reports radiation alone on operable cases is more frequently reported than surgery alone; though a combination of the two is more often employed than either method alone. Adair¹³ reports ninety-one five-year cures among 197 patients—a percentage of 46. But this percentage is not based on the entire material available at the hospital but what seems to be a very small fraction of it. He reports 500 cases or more a year as passing through their clinic. The results from surgery alone seem surprisingly poor. There were twenty-three radical mastectomies with two five-year cures—a crude result of 8.7 per cent. cures; or, after deducting four deaths from intercurrent disease, a rate of 10 per cent. is extracted. We are left to conclude that the poor result of surgery may depend on a chance dependence on the smallness of the series, or that they have been unfortunate in the selection of cases.

Lee's¹⁴ best results after five years are recorded for pre-operative irradiation, surgery, and post-operative irradiation combined, the number of cases being forty-one and the percentage of five-year cures 39. All things considered, their results seem no great advertisement for their varying methods of applying irradiation as compared to routine operative surgery in unselected cases.

Impressions which may need revision with time are:

(1) The cures from cancer of the breast are not proportionate to the time devoted to operation or to the extent of the local mutilation.

(2) Improvement in results in the future is not to be hoped from making our surgery more radical.

(3) Irradiation by the different methods at present in use has not demonstrated a replacement value as compared to surgery.

(4) Cures depend on earlier operation of reasonable extent and even more on a mystical something which pathologists are now exploring and which is spoken of as the biology of the tumor.

A series of 218 unselected cases of carcinoma of the breast have been submitted to operation. In 67 per cent. of these the axillary nodes were involved. In thirteen patients the operation is recorded as incomplete, and in several others supraclavicular glands were involved. 23.9 per cent. of the patients operated on over ten years ago survived the ten-year period and some of these are now living from ten to nineteen years from the date of operation. 37.8 per cent. of a series of patients, which includes a number not usually classed as operable, have passed the five-year period. The results compare favorably with those of well-known operating surgeons and seem quite as good as the results of those who largely replace surgery by irradiation. I have no intent to replace operative surgery in operable cases by any form of radiation, but hope to continue the operative treatment with as much aid from radiation as the methods now in use or to be developed may offer.

BIBLIOGRAPHY

- ¹ Lewis, Dean, and Rienhoff, W. F.: Results of Operations at the Johns Hopkins Hospital for Cancer of the Breast. *ANNALS OF SURGERY*, vol. xcv, p. 336, March, 1932.
- ² Handley, W. Sampson: Parasternal Invasion of the Thorax in Breast Cancer and Its Suppression by the Use of Radium Tubes. *Surg., Gynec. and Obst.*, vol. xlv, p. 721, December, 1927.
- ³ White, William C.: Late Results of Operation for Carcinoma of the Breast. *ANNALS OF SURGERY*, vol. lxxxvi, p. 695, November, 1927.
- ⁴ Lane-Clayton, Janet E.: Reports on Public Health and Medical Subjects, No. 51. Late Results of Operation for Cancer of the Breast. Ministry of Health, 1928.
- ⁵ Coughlin, William T.: Plastic Reconstruction of the Axilla in the Operation for Cancer of the Breast. *Surg., Gynec. and Obst.*, vol. xlv, p. 523, October, 1927.
- ⁶ Klingenstein, Percy: Late Results in the Operative Treatment of Carcinoma of the Breast. *ANNALS OF SURGERY*, vol. xcvi, August, 1932, p. 286.
- ⁷ Handley, W. Sampson: Cancer of Breast and Its Treatment. Second edition, Paul B. Hoeber, 1922.

RESULTS OPERATIONS FOR BREAST CANCER

- ⁸ Lee, B. J.: Irradiation of Mammary Cancer. Arch. of Surg., vol. xxiv, No. 3, p. 339.
- ⁹ Sistrunk, W. E., and McCarthy, W. C.: Life Expectancy Following Radical Amputation for Carcinoma of the Breast. ANNALS OF SURGERY, vol. lxxv, p. 61, 1922.
- ¹⁰ Bloodgood, Joseph C.: What Every Member of the Medical Profession Should Know About Protecting Women from Death from Cancer of the Breast. N. Y. State Med. Jour., vol. xxxii, No. 5, p. 259.
- ¹¹ Keynes, Geoffrey: Radium Treatment of Carcinoma of the Breast. Brit. Jour. of Surg., vol. xix, No. 75, p. 415, January, 1932.
- ¹² Pfahler, George E.: Results from Radiation Therapy in 1,022 Private Cases of Carcinoma of the Breast from 1902 to 1928. Amer. Jour. of Roentgenography and Radium Therapy, vol. xxvii, No. 4, p. 497, April, 1932.
- ¹³ Adair, Frank E.: Treatment of Metastatic and Inoperable Mammary Cancer. Amer. Jour. of Roentgenography and Radium Therapy, vol. xxvii, No. 4, p. 517, April, 1932.
- ¹³ Adair, Frank E.: The Results of Treatment of Mammary Carcinoma at the Memorial Hospital. ANNALS OF SURGERY, vol. xcv, p. 410, March, 1932.
- ¹⁴ Lee, Burton J., and Cornell, Nelson W.: A Report of Eighty-seven Primary Operable Cases of Carcinoma of the Breast Admitted to New York Hospital Prior to April 1, 1919. ANNALS OF SURGERY, vol. lxxx, p. 400, 1924.
- ¹⁵ Moschcowitz, *et al.*: Late Results After Amputation of the Breast for Carcinoma. ANNALS OF SURGERY, vol. lxxxiv, p. 74, 1926.

WHEN SHOULD IRRADIATION WITH RADIUM OR X-RAY PRECEDE OPERATION OR BE EMPLOYED WITHOUT OPERATION?

BY JOSEPH COLT BLOODGOOD, M.D.
OF BALTIMORE, MD.

THIS title was chosen, the paper planned, and much of my evidence accumulated some time in January, 1932, but very shortly after an invitation came to present a paper in Paris on April 26 before the French League Against Cancer on the activities in this country for the control of cancer. As I accepted this invitation I was compelled to drop further study of the material for my paper to be delivered before the American Surgical Association in May. On arriving in London, after ten days' study of the radium problem in Paris, I was so much impressed with the work of London surgeons in their treatment of cancer of the breast and cancer of the mouth and larynx with interstitial needles containing radium salts, that I postponed my return home and cabled the American Surgical Association my inability to present my paper in person. In response to an urgent message from the ANNALS OF SURGERY inquiring about the paper for publication, I am writing a very brief report, but this will include my observations in Paris and London, my wider reading of the literature while abroad and the careful study of the splendid, even remarkable, report of the Royal Commission of the Province of Ontario on the methods of the treatment of the sick with X-rays and radium.

For some years, after a very large experience with sarcoma of bone, I have urged that irradiation with deep X-rays should precede biopsy or any further operation, when the X-rays suggest malignancy. The chief reason for trying irradiation first for sarcoma of bone is that in a certain number of cases cures have been accomplished—not many, but a few, and among these cures are not included the cases of benign giant-cell tumor. The deep X-ray therapy is available all over the country, so there is no difficulty in beginning the treatment at once and in giving the patient the benefit of a full trial while the diagnostic survey and consultation are going on. In one of my own cases in which there was great difference of opinion as to the nature of the disease, even after biopsy, the boy's limb was saved by pushing deep X-ray therapy to its limits. We have not had sufficient experience to state that a four-gram pack offers any more than deep X-ray therapy, but I have records of three cases in which smaller amounts of radium were employed. In one case in which there was no biopsy, the patient is living eleven years after treatment. Then there are two cases in which the biopsy demonstrated that the tumor was a small, round-cell sarcoma of the Ewing type. One of these patients is alive and free from recurrence six years,

IRRADIATION OF CANCER

and the other lived four years without local recurrence, but succumbed to metastasis to the lung. I have discussed this again and again in the literature. The evidence is summarized in two chapters in Geschickter's book on bone tumors published by the American Journal of Cancer.

I repeat and emphasize that, with our knowledge as it is today, it is distinctly best to begin the treatment of every bone lesion which, in the X-ray,



FIG. 1.—Keynes' method of needling cancer of the breast by three radium needles near sternum, following the technic of Sampson Handley of London, who has employed these for ten years after operation. (Godfrey Keynes, in the British Journal of Surgery for February, 1932.)

J. L. Poulton.

is suspicious of malignancy, with a thorough and complete course of irradiation.

Cancer of the Breast.—I doubt if we need any more statistical studies to inform us what operation will accomplish in cancer of the breast. No one has improved on Halsted's statistics, which in the beginning dealt with late cases, and as Halsted's five-year cures increased the explanation was not better surgery, but a larger number of cases without metastasis to the glands

in the neck and axilla. Before we excluded border-line tumors from Halsted's statistical studies, the percentage of five-year cures after operations performed by himself or his associates, in which the glands were not involved, was 85. When, in 1915, I excluded the border-line tumors, as recently published in the *American Journal of Cancer*, the figure reduced to 70 per cent. This corresponds pretty closely with the statistical figures in the world's literature today. When the axillary glands are involved, as proved by the microscope, the five-year cures fall to 20 per cent., and the ten-year cures, as recently brought out by Lewis and Rienhoff, to 10 per cent. I had a very large personal experience from the very beginning with post-operative irradiation after operations for cancer of the breast in which the axillary glands were involved. It has been my rule not to use irradiation when the axillary glands are not involved, so it must be distinctly understood that my conclusions are based upon cases in which the chances of a five-year cure are about 20 per cent. after operation only.

I have been unable, in this group of cases, to find out that post-operative irradiation with deep X-rays has increased the five-year cures, or reduced the number of local recurrences, no matter what the explanation. I mean by this local recurrences due to incomplete chest-wall dissection in favorable or unfavorable cases, and local recurrences which are better explained by the extensive local involvement at the time of the operation and which take place no matter how painstaking the chest-wall dissection, or whether this dissection is done by knife, cautery or electric needle. Greenough, of Boston, in his investigations of his own material and of that collected by him as Chairman of the Committee on Cancer of the American College of Surgeons, agrees with my conclusions. Burton J. Lee, in his more recent papers and after his unusual experience, is not satisfied with post-operative irradiation after operations for cancer of the breast, but has substituted pre-operative irradiation and employs radium instead of deep X-rays. In France and England and throughout the world, there has been an immense experience with post-operative irradiation with deep X-rays. Sampson Handley still uses post-operative deep X-ray therapy, and is so modest that he does not realize that his results are due to his surgery and not to diathermy and irradiation. Williams, of St. Thomas' Hospital, in London, has compiled the largest statistics and has made no differentiation between "glands involved" and "glands not involved." I spent some hours with him over his tables. His conclusions agree with mine—there is no increase in the number of five-year cures and no decrease in local recurrences. It is only fair to state that the majority of his patients were in the later stages of cancer of the breast with involved glands, all clinically malignant. I spent an afternoon with Geoffrey Keynes, of St. Bartholomew's Hospital, in London. His most recent paper on the treatment of cancer of the breast by the insertion of radium needles was published in the February, 1932, number of the *British Journal of Surgery*. Doctor Keynes was good enough to send for a large number of his cases and allowed me to examine them with him, and

later to study the pathology of the biopsy, or where for some reason the breast had been removed. It is important to remember that in the cases of cancer of the breast treated by Doctor Keynes, the clinical diagnosis of malignancy was positive. In the majority of the patients the disease was late, the skin was adherent or ulcerated, the glands palpable. In spite of this, a large percentage of these patients are living and are clinically well; none are suffering with lymphedema of the arm. They were all happy and free from pain. Now and then, when a breast was secondarily removed because there was still an indurated mass, no cancer was found in the sections. There has been little or no study of the glands with the microscope. The point which impressed me most was this: Here is a method of treatment that promises just as much comfort with much less risk of post-operative complications, especially lymphedema, than an attempt to cure late cancer by the complete operation; and I feel confident that this method of interstitial irradiation or of needling the breast, or some other form of irradiation, will ultimately take its place as a palliative treatment rather than operation for cancer of the breast. At least it can be tried first. This is a method I am now employing when the clinical picture of the malignant tumor of the breast indicates that the chances of a cure by operation are not only small, if any, but the necessary dissection would be done at considerable risk of being followed by that distressing complication, lymphedema of the arm.

My personal experience with pre-operative irradiation is small. In a few of the cases a complete operation has followed. In a larger number, because of definite hopeless signs, no operation has been performed.

If my colleagues think anything of my experience in this matter, I hope they will understand me correctly when I urge them to cease using extensive surgery as a last resort in the treatment of extensive cancer of the breast. Our experience with irradiation with deep X-rays, or radium in its different forms, is sufficient to justify us in using this non-operative treatment, for at least palliation. Incomplete operations for cancer of the breast never cure and often make the patient much more uncomfortable than after no treatment at all.

When one explores a doubtful lump in the breast and finds it malignant, the entire evidence favors the complete operation, or, if the cancer of the breast has been of short duration and is clinically in the earliest stages, there seems to be no objection to giving pre-operative treatment to be followed later by the complete operation. This is, as yet, purely experimental, and at the present moment I am giving preference to operation in all early cases.

In a few years more our colleagues in London will be able to inform us on the results of needling cancer of the breast in its early stages. If their percentage of five-year cures is more than 70 and they have biopsies to prove that the lump was cancer, they will have sufficient evidence to justify the procedure.

Cancer of the Cervix.—I know that a number of my gynæcological col-

leagues in this country still operate on very early cancer of the cervix, a very few give a preliminary treatment with radium. Dr. Victor Bonney, of Middlesex Hospital, still operates and performs a Wertheim. Fortunately, it was my privilege to witness Doctor Bonney perform his operation—a masterpiece of surgical technic. I took the liberty of telling him that if the results of radium treatment were better than his results, no longer would anyone be justified in using surgery for cancer of the cervix. In spite of this the consensus of opinion of the world's authorities favors the treatment of cancer of the cervix with radium combined with deep X-ray therapy in

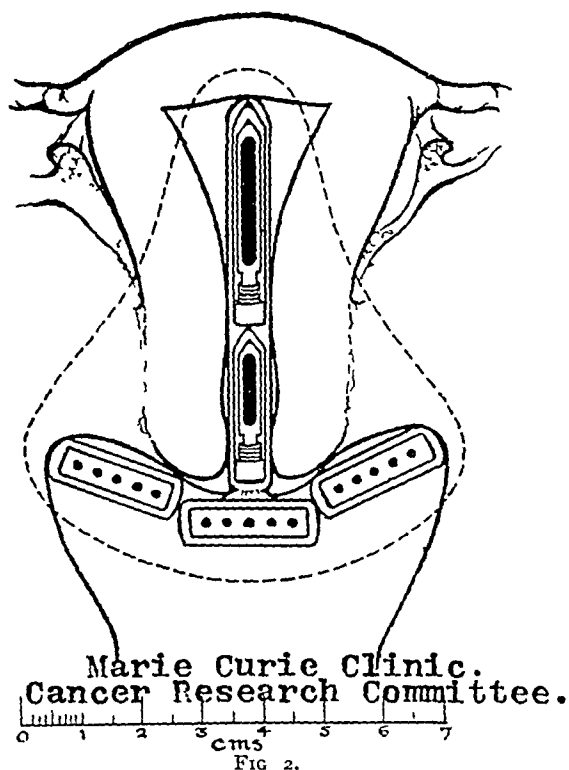


FIG 2.

FIG 2.—The dotted line shows the zone of effective radiation with the radium placed in position for the treatment of cancer of the cervix. (Radium Treatment of Cancer of the Uterus, Report of the Cancer Research Committee H K Lewis, Ltd, London, 1929)

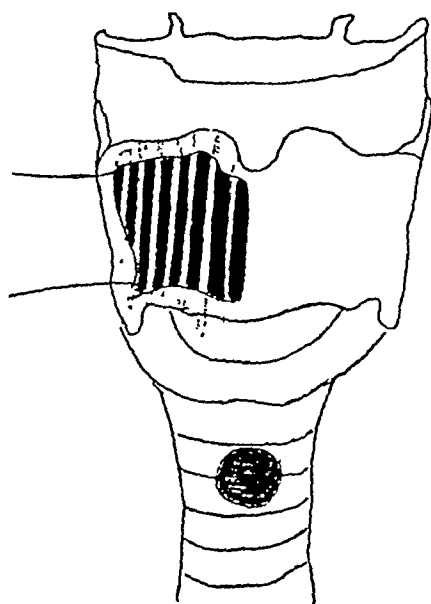


FIG 3

FIG 3.—Harmer method of placing needles into a fenestrum made in the cartilage of the larynx (Practitioner, January, 1930)

late cases. The results today in all cases, in the great clinics, are recorded at about from 33 to 35 per cent. of cures at the end of five years, but this cannot be compared with surgical statistics, because radium is employed in all cases, even in the hopeless and inoperable ones, while surgery is employed in only the early cases, or the so-called Group II, as classified by the League of Nations Committee.

My personal opinion is that the evidence favors radium treatment. Even when the cancer of the cervix is discovered by biopsy only, radiation seems to offer just as much as surgery with less risk.

It must be emphatically stated here that the danger of failing to cure a very early case of cancer of the cervix in the hands of an inexperienced

and untrained radiologist is just as great, if not greater, than the danger of post-operative death after a Wertheim operation performed by an inexperienced surgeon. The cure of cancer of the cervix depends upon the training of the surgeon and of the radiologist. Unfortunately for women with cancer of the cervix today, we have too many trained operators, and not enough trained radiologists.

Cancer of the Oral Cavity.—Unfortunately the majority of radiologists, whether they are also trained surgeons or not, fail to realize that the earliest stage of cancer in the oral cavity is usually an operable lesion just like the pre-cancerous lesion of the oral cavity, and that it is just as easy to completely remove the visible, palpable spot with a sufficient margin of healthy tissue with the cautery, electric needle. or even, in some areas like the lip,

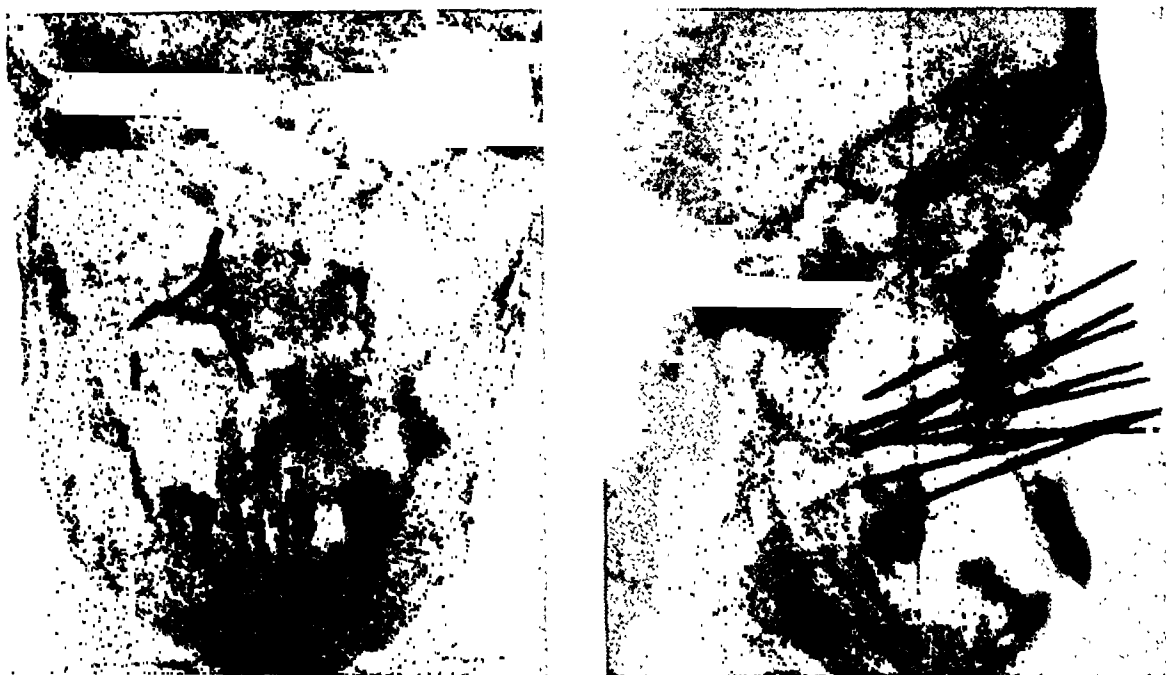


FIG. 4.—Shows method of introducing needles into the antrum for cancer of upper jaw. I examined, with Mr. Harmer, a number of apparently four- and five-year cures after this method. (*Acta Radiologica*, Vol. X.)

with the knife, as to treat it with radium. This complete excision of the small benign or early malignant lesion, properly performed, should accomplish a cure in every case, except in those few cases of cancer in which the glands may be involved.

However, in all cases of cancer of the oral cavity which has extended beyond the possibility of easy operative removal, irradiation with radium is the treatment of choice today. Surgery has accomplished cures in such cases, but always with more discomfort and more mutilation. In spite of my extensive experience over many years with this form of surgery, with knife, cautery and electric needle, I have given it up in favor of irradiation.

I will not take time or space to discuss the different types of irradiation of the oral cavity. We must look upon the introduction of irradiation as a great achievement in the treatment of cancer of the oral cavity. Many cures have been accomplished, whereas, if surgery had been employed, there would

have been greater discomfort, greater mutilation and, perhaps, a smaller percentage of permanent cures. I am speaking now of local cancer without involved glands. When the glands *are* involved, the best chances of a permanent cure depend upon their ultimate complete removal. If the involved glands are metastases from a cancer of the lower lip, the five-year cures are 50 per cent., while when the primary lesion is of the tongue or of the floor of the mouth, the five-year cures are 10 per cent. I am unable to obtain evidence as yet to inform us whether pre- or post-operative irradiation with X-rays or radium increases the number of five-year cures. There is no objection to giving the patient the benefit of both, but there is no question that in those cases in which the complete removal of the glands is possible, operation offers most, and as a rule one must attempt it to find out if the glands can be removed.

Cancer of the Larynx.—I was very much impressed with the results of treatment of cancer of the larynx by Mr. Harmer. It was my good fortune to examine a number of his cases in which the treatment dated back three to five years. The larynx and the cords appeared normal. The patients were clinically well. No glands had been removed and no glands were palpable. I witnessed operations by Mr. Harmer and Mr. Cade. First, there was general anæsthesia with gas-oxygen through an intratracheal tube, most expertly administered. Then, on one or both sides of the larynx, according to the extent of the growth, a piece (fenestrum) was removed from the cartilage, and into this area were placed a sufficient number of needles loaded with radium salts. The method is, of course, simpler than laryngectomy. To me, the results were marvelous, and if the ultimate statistics prove that the results are as good as after laryngectomy, cancer of the larynx will have lost most of its horrors.

Soft-Part Tumors Anywhere.—I have made some contributions to these before, but a brief résumé of the rationale of testing all palpable nodules with X-rays or radium explains best the value of pre-operative irradiation with X-rays or radium. For example, let us take a small nodule near a great nerve trunk—median, ulnar, popliteal, sciatic. In the first place, we know that these nerve-sheath tumors may be multiple. Many of the local recurrences, or recurrences near the scar after the removal of a nerve-sheath tumor, whether benign or malignant, can be explained by leaving behind one or more smaller tumors of the same kind which were not exposed when the larger one was removed. Our records show numerous such examples. Second, irradiation may be followed by the disappearance of the tumor, or after getting smaller it may remain stationary. In a number of instances, rather than resect the involved nerve, we have succeeded in keeping the tumor small and not growing for years under repeated irradiations with X-rays or radium.

Perhaps most important of all, when an apparently small and operable tumor is properly irradiated and does not disappear or show any evidence of becoming smaller, and then the tumor is explored and the operator dem-

IRRADIATION OF CANCER

onstrates that the complete removal means resection of a motor nerve, or of a vessel involving the circulation of a limb, the operator is justified in proceeding with that complete resection. There is no difficulty in getting the exact nature of the tumor. If biopsy proves it to be malignant, there is no choice; if benign, one may attempt to remove all of the growth possible without injury to the nerve or vessel and then depend upon a tendency of the remaining benign tumor to remain quiescent, or be held by post-operative

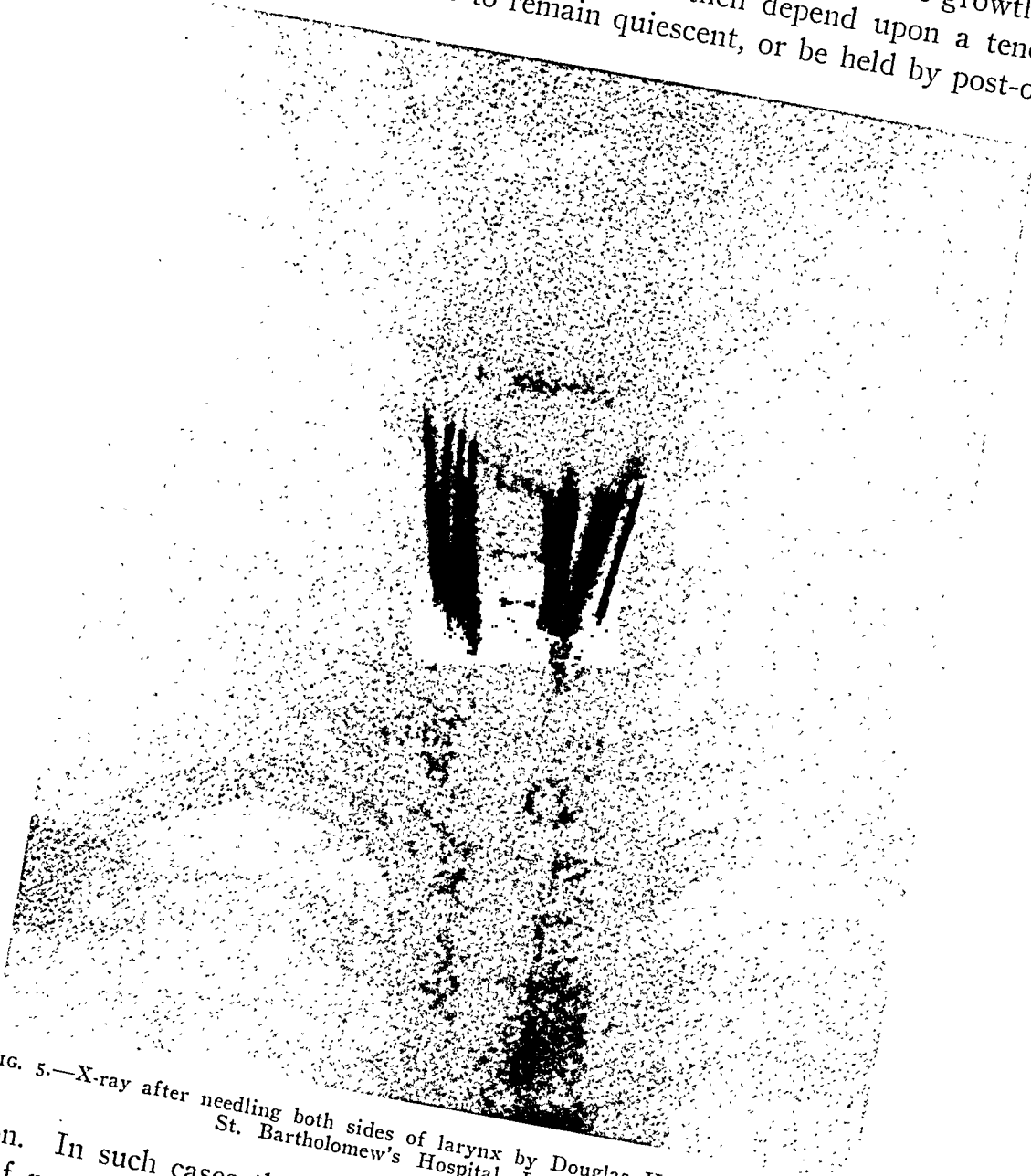


FIG. 5.—X-ray after needling both sides of larynx by Douglas Harmer, surgeon at St. Bartholomew's Hospital, London.

irradiation. In such cases there is no danger of metastasis, but ultimately, because of recurrence, complete resection may have to be performed. The soft-part tumor may be large; its removal may mean amputation or mutilating resection. It may be present within the abdomen or the chest, or involve important structures of the neck. It is far better to give these tumors pre-operative irradiation without preliminary biopsy or exploration, because in many cases the tumor disappears and does not recur. Many of these cases have been held, and held for years, by repeated irradiations.

I am confident that the decision to operate first, or irradiate first, or do a biopsy first, is largely influenced by who sees the patient first. Therefore, the ideal arrangement is for the general practitioner or family physician to refer his patient to a tumor clinic where the patient will come under the diagnostic supervision of a staff rather than an individual. It is also essential that financial considerations should not influence diagnostic and therapeutic procedures. This undoubtedly is less apt to happen in a clinic.

As this paper must be mailed now, it cannot be lengthened. In the larger paper to be published all that can be added will be the evidence on which these somewhat dogmatic statements are made. I urge my surgical colleagues who perhaps have not given the same time or had the same opportunity to investigate the remarkable advances made in the treatment by irradiation with X-rays or radium, to give consideration to irradiation with X-rays or radium by competent radiologists before surgical intervention and often even before biopsy. It can be employed just as the old therapeutic test for syphilis has been employed in the past.

As the number of patients increases whose local lesion is clinically of small extent and who give a history of signs or symptoms of short duration, the chances of curing the lesion, if it is malignant, increase very greatly as, due to the difficulties of diagnosis, microscopical, and the choice of method of treatment of the local lesion, no harm can be done by pre-operative irradiation in the hands of a trained radiologist, but much harm can be done by an unnecessary operation at the hands of the greatest and most expert surgeon.

INOPERABLE AND MALIGNANT TUMORS*

BY WILLY MEYER, M.D.

OF NEW YORK

THE principal phases in the evolution of medicine and allied sciences within the last one hundred years have left their lasting imprint on the cancer problem. Naturally pathology was in the lead. The teachings of Theodor Swann, originally of Halle, Germany, later in Liège (Louvain), that cells plus medium had to be considered; the teachings of Carl Rockitsky of Vienna in the '40's, that the humors (or medium) were at the bottom of diseases generally; the teachings of Rudolf Virchow of Berlin in the '50's, erecting the cellular pathology, are reflected in the writings of many authors on cancer up to the present time. The unexplained rôle of a group of cells, suddenly and mysteriously turning into disorderly growth, destroying their neighbors, putting themselves in their place, then slowly but surely undermining the health of their host, are discussed up to this day.

Then came the era of bacteriology founded by Pasteur, Lister, Koch and other schools, beginning in the late '60's, which naturally made medical men who had to treat cancer patients and the scientists of the affiliated branches ponder: cancer, too, must be produced by a living organism. Up to this very time brilliant minds here and abroad cling tenaciously to the infectious theory.

Gradually the advance of organic chemistry brought forth the newest branch of medical science, biology, with its adjuvants: biological chemistry, biological physics, biological physical-chemistry,—a thorough study of the living organism, all of them seconded by physiology, pathology and cancer research.

The treatment of cancer also reflects these various theories of the last one hundred years.

Today we are in the midst of the biological treatment of cancer in coöperation with biological chemistry and biological physics as far as inoperable cancer is concerned.

Operations on operable malignant tumors, of course, remain within the domain of modern cancer surgery. By cancer surgery the tumor "cancer" with all the anatomical groups of regional lymph-nodes are removed and in many instances the patient appears to remain clinically cured. If a biological systemic after-treatment were added in *every* instance, we believe the majority of such patients would remain cured after a properly conducted radical operation.

* This paper, written by Dr. Willy Meyer a few days before he died in February, 1932, had been announced by him to be read before the American Surgical Association Meeting at New Haven in May, 1932, and was read by title.

Personally we have accepted as a good and working hypothesis the assumption that cancer grows only in an alkaline medium and not in an acid medium.

Following this lead, we are trying to change the increased alkalinity of the blood, which was found in every one of the cases of advanced carcinosis studied by us within the last six months, over towards and into the sphere of acid reaction of the blood.

Careful clinical observation and reliable intermittent determination of the pH of the blood of the patient as far as science has advanced in this field today has been our guide.

Biological treatment as practised at the Lenox Hill Hospital at present is principally represented by artificial fever with the help of the large General Electric Corporation "Radiotherm," the inhalation of a mixture of oxygen and carbon dioxide, 94.5:5.5 per cent., deep X-ray therapy, ketogenic diet, intramuscular and intravenous injection of gluconate of calcium, and ammonium benzoate per os.

At this time we believe that, as soon as clinical examination or operation has proved the disease to be beyond the reach of the knife, the biological (acidotic) treatment should set in. In far advanced cases it seems that lacking metabolism balks correction. These patients will die at present.

May we say in conclusion: Those who believe that the so-called inoperable cancer patients should be treated on biological principles seem to be on a possibly correct track. But this big experimental task is neither that of a few men nor of a few hospitals. It is the task of all colleagues who can see a modicum of truth in these assumptions, a possible lead out of the cancer labyrinth. The hospitals and research laboratories of the world should join and help in advancing this big problem as carefully and as rapidly as possible in the interest of suffering humanity.

ULCERATION OF ABERRANT GASTRIC MUCOSA IN MECKEL'S DIVERTICULUM

AS A SOURCE OF INTESTINAL HÆMORRHAGE

BY JAMES M. MASON, M.D.

AND

GEORGE S. GRAHAM, M.D.

OF BIRMINGHAM, ALA.

PRIOR to 1903, intestinal hæmorrhage originating in ulceration of Meckel's diverticulum had not been observed, and not until the report of Deetz,¹ in 1907, had the relation of aberrant gastric mucosa to ulcer of the diverticulum been considered. The acceptance of peptic ulcer of Meckel's diverticulum as a definite clinical entity and the importance of intestinal hæmorrhage as a symptom thereof has resulted from a careful study of an increasing number of cases which are found to present a uniformity of symptoms and histological findings. Much of the evidence is very recent. Between 1903 and 1922, seven cases of intestinal hæmorrhage from ulcer of Meckel's diverticulum were reported at irregular intervals. This paper is based on a consideration of these cases and of twenty-six others, including one of my own, which have been reported since 1924, and the number is now sufficiently large for one to draw conclusions. The disease is one of infancy and childhood. In only one of the adult cases reported does the history fail to go back to childhood as the starting point of intestinal bleeding; and in that instance the patient, aged forty-one years, had suffered since the age of seventeen with digestive disturbance, and for eleven years with recurring intestinal hæmorrhages.

The tangible clinical symptoms are intestinal hæmorrhage of unexplained origin and abdominal pain of vague and indefinite character. The pathological findings are the presence in the diverticulum of aberrant gastric mucosa, and ulceration located in the area where gastric and intestinal mucosa merge. The course of the disease tends to ulceration of the mucosa, erosion of blood-vessels, penetration of the diverticular wall, and perforation into the peritoneal cavity.

Peptic ulcer may occur without intestinal hæmorrhage, but as this paper deals more particularly with the symptomatic value of intestinal hæmorrhage associated with peptic ulcer, I shall not go into the question of peptic ulcer unassociated with hæmorrhage. In such instances there are no pre-perforative symptoms which will lead to a correct diagnosis, and neither has X-ray nor any other laboratory agency proven of value in revealing the presence of a Meckel's diverticulum. These cases come to operation when signs of acute abdominal disease demand exploration, and a perforation of the diverticulum is usually found.

Meckel's diverticulum is present in approximately 2.5 per cent. of humans, and largely predominates in males.

There are three main types, and, Christie,² from a study of sixty-three autopsy specimens from the laboratory of the Baby's Hospital, N. Y., gives the following percentages: Type 1—The umbilical fistula, 6.3 per cent. Type 2—Partial obliteration with fibrous band running from the tip of the diverticulum to the umbilicus or some adjacent structure, 10 per cent. Type 3—The typical diverticulum given off from the antimesenteric side of the ileum, lying free in the peritoneal cavity, and presenting a closed distal extremity, 82.5 per cent.

Less frequently observed are: Type 4—The giant diverticulum of bizarre form or shape, sometimes coming off from the mesenteric side of the ileum and developing between the folds of the mesentery. Type 5—The umbilical polyp, either attached to the remains of the omphalomesenteric duct inside the abdomen, or entirely cut off from internal connections.

In Types 1 and 5 the diagnosis is made by inspection and the indications for treatment are obvious. From Type 2 we obtain the greatest number of cases of obstruction. Type 3 gives rise to intussusception, volvulus and diverticulitis, and is the one in which peptic ulcer has been most frequently observed. Type 4 gives rise to problems peculiar to the individual case.

As recently as 1913, peptic ulcer of Meckel's diverticulum was not generally recognized; and neither Meyer,³ in 1912, nor Wellington,⁴ in 1913, mention the condition, though both carefully reviewed diseases of the diverticulum. Likewise, until very recently, so little attention had been given to the histology that the significance of aberrant gastric mucosa was not appreciated in the few instances in which it had been observed. Kelly and Hurdon,⁵ in 1905, Adami and Nicholls,⁶ in 1911, and Cullen,⁷ in 1916, say, "the walls and mucosa are similar to those of the intestine"; Adami and Nicholls adding that "the diverticulum may become strangulated or inflamed, or that it may perforate." Investigations of Schaetz,⁸ in 1925, changed our conception of the structure of these diverticula. He studied in serial section thirty diverticula, and found that in only seventeen, or 57 per cent., was the mucosa similar to that of the adjacent ileum. His further findings were as follows: Five, or 16.6 per cent., showed islands of gastric mucosa. One showed pancreatic tissue. Two showed both pancreatic tissue and gastric mucosa. One showed carcinoid mucosa. One showed mucosa of doubtful heteroplasia. As usually quoted, it is said that his statistics showed gastric mucosa in 16.6 per cent., whereas he found it in 23.3 per cent., the additional cases showing both gastric mucosa and pancreatic tissue.

Deetz states that Zenker found aberrant pancreatic tissue in a Meckel's diverticulum as far back as 1861, and this observation has been confirmed many times since. Its presence, so far, has given rise to no clinical manifestations. Bookman⁹ recently reported a carcinoma of the duodenum originating in an area of aberrant pancreatic tissue, and this gives rise to interesting speculation in regard to such possibility in a Meckel's diverticulum.

The earliest observation of aberrant gastric mucosa in the remains of the omphalomesenteric duct was that of Tillmanns,¹⁰ in 1881.⁷ He found this not a Meckel's diverticulum proper, but in an umbilical polyp. The case was reported as one of "Congenital prolapse of gastric mucosa through the umbilical ring." This explanation was accepted for a time, but further study of a series of similar cases proved that the gastric mucosa was in the remains of the omphalomesenteric duct, and that it did not result from herniation of gastric mucosa.

Cullen has summed up the evidence presented by the reported cases of umbilical polyps and is of the opinion that they are remnants of the omphalomesenteric duct.

Earliest Cases.—In 1903, Hilgenreiner¹² reported the case of a boy of eighteen years, who, since childhood, had had bloody stools at various times, and many attacks of severe abdominal pain. A tender mass appeared at the right of the umbilicus and a diagnosis of appendicitis was made.

At operation there was found a Meckel's diverticulum seven centimetres long attached by its distal extremity to the abdominal wall. It was resected, and was found to contain an ulcer which had penetrated deeply into the wall of the diverticulum. While it was not recognized as such, Stulz and Woringen,¹¹ in reviewing the case, say that the histological report, and especially the wood cut which illustrated the paper, shows that the case is one of chronic peptic ulcer.

In 1907, Deetz¹ made the first suggestion concerning the peptic nature of an ulcer in Meckel's diverticulum. A boy nine years of age became suddenly ill with symptoms of diffuse peritonitis, which was diagnosed as being due to perforation of the appendix. At operation the peritonitis was found to be due to perforation at the base of a Meckel's diverticulum. Histological examination showed the presence of gastric mucosa. There had been no intestinal bleeding.

His study of the case convinced him of the peptic nature of the ulceration, and in further comment he says: "It will be necessary in the future to search for gastric mucosa in extirpated diverticula," for "I imagine that in this form of diverticulitis when it comes to ulceration, conditions may be at work which are similar to those which are present in true gastric ulcer."

He says that he has found reference to only one similar case in the literature, that of Hildebrandt,¹⁶ recorded in *Charity Annalen*, 1905, and that Hildebrandt referred only casually to the finding of the aberrant gastric mucosa.

In 1911, Callender¹³ in an autopsy on an infant who died of intestinal hæmorrhage, made the first observation of a bleeding ulcer of Meckel's diverticulum in which the presence of gastric mucosa was definitely confirmed by histological examination. His case was not reported, however, until 1915.

In 1913, Hubschmann¹² reported the case of a boy who, following a fall on the abdomen, had intestinal bleeding for four weeks, followed by symptoms of peritonitis. At operation diffuse suppurative peritonitis was found, but the source of the infection was not discovered until autopsy. A perforated ulcer of Meckel's diverticulum was found with erosion of a blood-vessel. He made an exhaustive study of the pathological features of this ulcer, and classed it as a definite peptic ulcer, and demonstrated in the sections the presence of gastric mucosa.

In 1914, Griffith¹⁴ published the first detailed report in American literature of ulceration of Meckel's diverticulum where intestinal hæmorrhage was a marked symptom and where autopsy confirmed the source of the bleeding. He mentions Hubschmann's case of peptic ulcer, but lays no stress on peptic ulcer as a probable factor in his own case, and submits no histological studies.

These early cases may be considered somewhat fundamental in establishing intestinal hæmorrhage as a symptom of ulceration of Meckel's diverticulum and the presence of gastric mucosa as a cause of the ulceration. The cases in this report give ample confirmation to these claims.

In stressing the diagnostic importance of intestinal hæmorrhage, we must review the relation of hæmorrhage and pain to time of operation or autopsy. In one instance (Abstract No. 5) pain of fourteen days' duration was followed by intestinal hæmorrhage and signs of suddenly developing peritonitis. A perforation was found. In one instance (Abstract No. 18) recurring hæmorrhages had been noted for twelve years. An inflamed diverticulum, supplied with large vessels, was found, but the presence of an ulcer was not

demonstrated. In nine cases with acute onset, hæmorrhage and pain appeared at practically the same time (Abstracts Nos. 4, 14, 16, 21, 22, 24, 25, 31 and 33). Four of these showed perforated ulcers (Abstracts Nos. 14, 16, 22 and 31), and five showed ulcers in various pre-perforative stages. In the remaining twenty-two, autopsy or operation was preceded by hæmorrhage for periods varying from a few days to many months, or even years. In these twenty-two cases were found twelve perforated ulcers. In every instance operation could have been carried out at a pre-perforative stage, with a vastly lowered mortality, if the diagnostic significance of intestinal hæmorrhage had been fully appreciated.

Two cases present features of unusual interest and are reported in brief to emphasize the importance of intestinal bleeding as an indication of ulceration of the diverticulum; also, as pointing to the necessity of removing wherever possible all diverticula found in the course of abdominal operations.

The case of Brasser, 1924 (Abstract No. 8). Pain in lower abdomen; ten days later repeated hæmorrhages; operation revealed colon filled with blood but the source was not ascertained and the abdomen was closed: Death from peritonitis eight days later. Autopsy. Perforation of Meckel's diverticulum.

The case of Winkelbauer, 1929 (Abstract No. 24). Abdominal pain followed by bloody stool. Diagnosis, intussusception; operation; diverticulum with band incarcerating ileum; band divided and incarceration relieved. Intestinal bleeding continued, and two months later the abdomen was reopened, when an intussusception of the diverticulum into the ileum was found. The diverticulum showed a peptic ulcer which had eroded a vessel.

The case of Pascale (Abstract No. 15) is also of special interest on account of the findings. In a woman of forty-one years with history of digestive disturbance since seventeen years of age, and of intestinal hæmorrhage since the age of twenty-nine, a completely healed peptic ulcer of Meckel's diverticulum was found; the only one so far observed.

Histology.—Histological studies are reported in twenty-five instances. In twenty-three of these gastric mucosa was found.

In the case of Hilgenreiner (Abstract No. 1) the first bleeding diverticular ulcer recorded, nothing is said concerning the peptic nature of the ulcer, and the histological examination showed "normal structure of ileum, small intestine structure with hyperplasia of glands, lower villi, and more numerous goblet cells." Stulz and Woringer have reviewed this case and claim that the histological examination and particularly the cut which illustrates the paper prove the case to be one of chronic peptic ulcer.

In Winkelbauer's case (Abstract No. 25) the histological report states that, "The preparation showed a peptic ulcer with erosion of a branch of an artery." In the section examined, neither gastric mucosa nor pancreas tissue could be determined.

In eight instances no histological examinations were made. This omission was due in one instance to the necrotic state of the diverticulum making section impossible (Abstract No. 17); in another instance to the method of treatment, exteriorization of the diverticulum allowing it to be cast off after becoming necrotic (Abstract No. 16); in another, to the loss of the specimen in the laboratory (Abstract No. 11).

Operative and Autopsy Findings.—In the thirty-three cases analyzed, perforation was found in sixteen instances and in sixteen instances nonperforating ulcers were found. In one case an inflamed diverticulum was found but ulcer was not demonstrated.

Three perforating and two nonperforating ulcers were treated medically. All died; one, however, died from intercurrent disease.

HÆMORRHAGE FROM MECKEL'S DIVERTICULUM

TABLE I

Mortality

Total Cases	Recovered	Died	Mortality
33	22	11	33.33
Treated medically			
5	0	5	100.
Perforating ulcers treated surgically			
14	8	6	42.86
Nonperforating ulcers treated surgically			
13	13	0	00.
Inflamed diverticulum treated surgically			
1	1	0	00.

TABLE II

Peptic Ulcer of Meckel's Diverticulum, a Disease of Infancy and Childhood Appearing Principally in Males

Age and Sex in This Series

Males	28.	Females	3.	Sex Not Stated	2.
Ages					
In the first year.....					6
In the second year.....					8
From 3 to 5.....					4
5 to 10.....					4
10 to 15.....					8
Over 15.....					3
Total.....					33

The age of the youngest was fifteen weeks and of the oldest forty-one years.

In those patients over fifteen years, the ages were eighteen, twenty-eight, and forty-one, respectively.

In the first two the history of intestinal bleeding went back to early childhood. In the patient of forty-one years of age, digestive disturbances had been noted since the age of seventeen, and bleeding since the age of twenty-nine.

TABLE III

Pre-operative Diagnoses

Appendicitis.....	2
Intestinal obstruction or intussusception.....	7
Ulceration of intestinal tract.....	4
Ileocecal tuberculosis.....	2
Intestinal polyp or tumor.....	1
Exploration to ascertain source of hæmorrhage or peritonitis.....	13
Bleeding from ulceration of Meckel's diverticulum.....	4
Total.....	33

The four cases correctly diagnosed before operation were reported since 1927.

These correct diagnoses were evidently due to a wider recognition of intestinal bleeding as symptomatic of ulcer of Meckel's diverticulum.

Greenwald and Steiner (Abstract No. 32) made their diagnoses on the history of bleeding and pain, and confirmed the diagnosis of perforation by fluoroscopy, when they found a column of air between the liver and the diaphragm.

TABLE IV

Treatment Consists in Removing the Diverticulum in the Manner Best Suited to the Individual Case

In This Series the Following Methods Were Employed
with the Results Noted

	No.	Rec.	Died
Drainage: perforation found at autopsy.....	2		2
Exploration: abdomen closed. Perforation found at autopsy.....	1		1
Drainage: Secondary removal of diverticulum.....	1	1	
Suture of ulcer: secondary removal of diverticulum.....	1	1	
Diverticulum fixed in wound and allowed to slough.....	1		1
Resection of intestine with diverticulum.....	4	4	
Resection of diverticulum.....	18	16	2
Treated medically.....	5		5
Total.....	33	22	11

CASE REPORT.—*Intestinal Hæmorrhage from Peptic Ulcer of Meckel's Diverticulum*.—Stanley W., white male, aged nine months, was sent to the Children's Hospital, of Birmingham, Ala., September 24, 1929, by Dr. S. P. Wainwright, who had seen him at home a few hours earlier. The child had enjoyed good health until one week before admission, when bowels became loose and watery. On the afternoon of September 24, he had a rather large bloody stool, and was taken to the hospital. He had a normal stool on the morning of the twenty-fifth, after which, bleeding recurred. On examination about 10:30 A.M., by Dr. Russell Callen, the Attending Pædiatrician, it was noted that the child was passing dark fluid blood unmixed with fæces. There were no other symptoms. The child was in good humor and showed no evidence of pain. He did not appear to be ill, except for marked pallor. The hæmoglobin was 46 per cent.; red blood count showed 2,200,000 cells; the total white count, 5,650; and the differential count showed small lymphocytes, 29 per cent.; large mononuclear lymphocytes, 10 per cent.; polymorphonuclear leucocytes, 61 per cent.

Physical examination by members of the pædiatric staff failed to reveal any cause for the hæmorrhage. A barium enema not only failed to render any diagnostic assistance, but proved actually misleading, in that the enema advanced only to the hepatic flexure, giving rise to the suspicion of a possible incomplete intussusception. Evidently an insufficient amount of fluid was employed or sufficient time had not elapsed for the enema to advance farther; for neither the history, the examination of the abdomen, nor the appearance of the patient bore out the diagnosis of intussusception; and examination of the hepatic flexure at operation showed no obstruction or other abnormality.

Exploration was carried out under ether at 5:30 P.M. The hepatic flexure was first examined for the reason above set forth. The appendix, quite normal in appearance, was removed. Further search revealed a Meckel's diverticulum thirty-five centimetres above the ileocecal valve. The lumen was almost that of the adjacent ileum; the length was approximately six centimetres; the tip was free and rather nodular. The diverticulum was removed as the possible source of the hæmorrhage. It was cut off flush with the ileum and the opening was closed with two rows of Lembert sutures. There was no blood in the diverticulum at the time of its removal. The patient made a prompt recovery.

Microscopical Description by Dr. George S. Graham.—The specimen was fixed without opening and sections were made longitudinally throughout its whole length. They show a pouch of intestine with normal muscular and serous layers in the wall. The base where the diverticulum was amputated from the intestine is lined by mucous

membrane of small intestine type. This is abruptly replaced at a short distance from amputated end by gastric mucosa with characteristic glands containing chief and parietal cells and gastric pits lined by mucus-secreting cells. This lines the whole remaining portion of the lumen on both walls and at the blind end. The submucosa and mucosa are elevated into several high folds. At tip of the diverticulum there is a relatively large mass of glandular tissue of pancreatic type. It lies for the most part outside the muscular coat of the diverticulum but a small lobule penetrates the submucosa. The duct system is well developed. On one lateral wall at the place where the two mucosal types meet the gastric mucosa is destroyed by ulceration. The destruction extends over a sector nearly one-fourth of the length of the lateral wall on which it is located. At the base of a submucosal fold it terminates in a deeper area of destruction within whose floor there is a small arteriole stuffed with red cells and partially surrounded by the necrotic tissue of the floor. Just beneath it are two other cross-sections of small arteriole, probably the same vessel. The intestinal wall beneath the ulcer is infiltrated

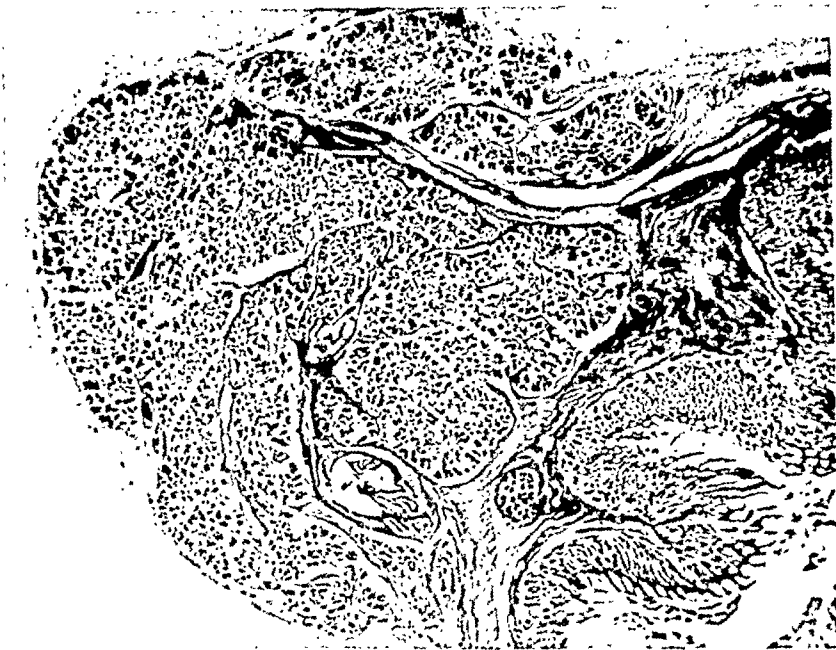


FIG. 1.—Mass of pancreatic gland tissue lying upon muscular wall at tip of diverticulum. ($\times 12$.)

to the peritoneal surface by large numbers of lymphocytes among which there is a considerable percentage of neutrophils and eosinophils. (Figs. 1, 2, and 3.)

Microscopical Diagnosis.—Chronic peptic ulcer in Meckel's diverticulum.

Cases of Meckel's Diverticula of Unusual Form, Size, and Development Which Have Been Associated with Intestinal Hæmorrhage Have Been Reported by Moll,⁴² Tisdall,⁴³ and Abt and Strauss.³²—The bleeding in these cases has probably come about by interference with the circulation of the intestine resulting from the unusual anatomical peculiarities rather than from ulceration. In Moll's patient the diverticulum was thirty-three inches long, and all layers of the small intestine were present. Two ulcers were found at the junction with the small intestine. In the patient of Tisdall's, a Meckel's diverticulum fifty-nine centimetres long was attached to the ileum forty-five centimetres above the ileocecal valve. The distal extremity was expanded into a pouch as large as the stomach. Many gastric cells were present but there was no ulceration. In the case of Abt and Strauss the diverticulum was eighteen inches in length and had developed between the leaves of the mesentery. There was no ulceration and the sections showed only intestinal mucosa.

The Question of Ulceration and Hæmorrhage Without the Presence of Aberrant Gastric Mucosa.—The cases of Hilgenreiner and Winkelbauer raise the question of bleeding from ulcers other than those showing aberrant gastric mucosa.

Hilgenreiner did not mention the finding of gastric mucosa in his case, but, as already noted, Stulz and Woringer claim that the case is one of proven chronic peptic ulcer.

Winkelbauer diagnosed his case as one of peptic ulcer, but says that "in the sections examined neither gastric mucosa nor pancreas tissue could be determined." One's only comment on this is that further search might possibly have revealed the presence of gastric mucosa.

The Claim is Made That Diverticulitis is Distinctly Different from Peptic Ucer.—The latter has a definite location in that area of the diverticulum or in the adjacent ileum where gastric mucosa merges with that of the ileum.

This ulcer, as Stulz and Woringer¹¹ hold, is "mostly of acute evolution, opening vessels, penetrating into neighboring organs and making its way toward the free peritoneum; it then perforates and provokes diffuse or limited peritonitis."



FIG. 2.

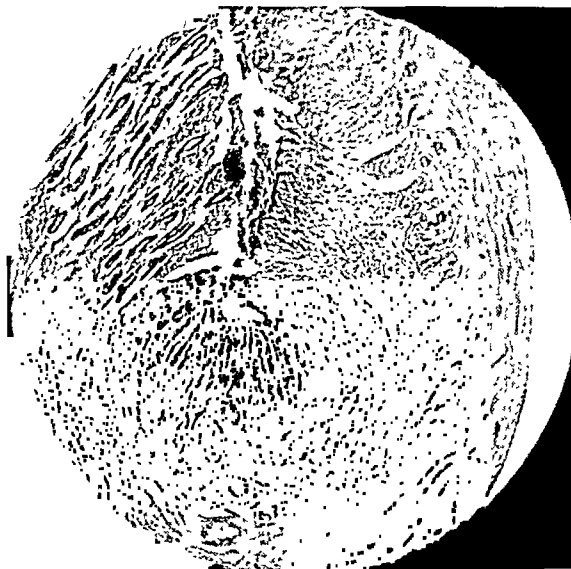


FIG. 3.

FIG. 2.—Mucosal ulcer. The ulcer begins abruptly at base of a ruga-like fold and extends almost to amputation level. ($\times 12$.)

FIG. 3.—Higher power view of ulcer margin. At base of zone of necrosis can be seen an engorged arteriole. ($\times 48$.)

We do not know the causes that lead to ulceration about these little areas of misplaced gastric mucosa, but the evidence is strong that the influence of the acid secretion from the gastric cells, as it comes in contact with the alkaline secretion from the intestine, causes a break in the mucosa and produces an ulcer which Hübschmann likens to the gastrojejunal ulcer following gastroenterostomy. These are questions for academic discussion by pathologists. The important surgical considerations are:

First.—To recognize that intestinal hæmorrhage of unexplained origin, especially occurring in a child, may be due to peptic ulcer of Meckel's diverticulum; that the tendency of the peptic ulcer is to perforate; and that operation should be undertaken before perforation has taken place.

Second.—In exploring for the purpose of locating the source of intestinal hæmorrhage or diffuse peritonitis, to remember that they are often to be found in Meckel's diverticulum.

Third.—To remove, whenever possible, any Meckel's diverticulum found at operation as a measure to prevent possible future trouble.

ABSTRACT OF CASES ANALYZED FROM LITERATURE

No. 1.—Hilgenreiner,¹⁰ 1903. Male, aged eighteen years. For several years violent attacks of abdominal pain with constipation and bloody stools. On one occasion there was a large intestinal hæmorrhage. A tender mass developed on the right side of the umbilicus, and a diagnosis of appendicitis was made. The mass was three by six centimetres in size. *Operation.*—The tumor proved to be a Meckel's diverticulum seven centimetres long attached by its distal extremity to the abdominal wall. The diverticulum together with the tumefied and inflamed area of abdominal wall was resected, with recovery.

On section there was found an ulcer which had deeply penetrated the wall of the diverticulum. *Histological Examination.*—In the central portion, normal structure of the ileum; in the peripheral, small intestine structure with hyperplasia of glands, lower villi, and more numerous goblet cells.

No. 2.—Hubschmann,¹² 1913. Male, aged four and one-half years. Abdominal trauma was followed by intestinal hæmorrhage for four weeks, when signs of diffuse peritonitis appeared. Operation revealed free pus in the peritoneal cavity but the source of the infection was not ascertained. At autopsy a Meckel's diverticulum four centimetres long was found. The tip was free and a perforating ulcer was found at the base. This had eroded a blood-vessel.

No. 3.—Griffith,¹⁴ 1914. Male, aged nineteen months. Infant under observation for three months for abdominal pain and intestinal bleeding. No diagnosis other than ulceration of intestinal tract. Death. *Autopsy.*—Meckel's diverticulum three centimetres long, lying in centre of an abscess. Mucosa showed an ulcer at tip, and purulent exudate on serous surface corresponded to location of ulcer. Tip was free. No histological studies.

No. 4.—Callender,¹³ 1915. Infant, nineteen months of age; death after thirty-six hours from intestinal hæmorrhage. *Autopsy report.*—Diverticulum two centimetres long attached by tip to posterior wall of cæcum. Punched-out ulcer 0.5 centimetre in diameter in ileum at border of diverticulum. At margin a small vessel is found plugged with clot. Mucosa shows gastric fundus glands.

No. 5.—Muller,¹⁷ 1919. Male, aged eleven years. For past fourteen days pain in right lower abdomen and slight diarrhœa. The following night he had severe pain and passed a very black stool. He was admitted at the hospital at 10 P.M. with a diagnosis of appendicular peritonitis. *Operation.*—Thirty-seven centimetres above the ileocecal valve was found a Meckel's diverticulum seven centimetres long with a perforation near the attachment to the ileum. The perforation was closed by suture and the abdomen was drained. Two months later a secondary operation was undertaken for the removal of the diverticulum. A segment of small intestine together with the diverticulum was resected, with recovery. Histological sections showed that the mucosa throughout its greater portion was similar to that of the fundus of the stomach.

No. 6.—Meulengracht,¹⁸ 1919. Male, aged twelve years. Ten days before admission to the hospital acute suppurative otitis media developed in connection with septic endocarditis. He had several attacks of indefinite abdominal pain with vomiting, and severe melæna appeared fourteen days before death and persisted for several days. *Autopsy.*—One hundred and twenty centimetres above ileocecal valve was found a Meckel's diverticulum. On the floor of the diverticulum was an ulcer one by one and one-half centimetres. The ulcer lay in the portion of the diverticulum lined with intestinal mucosa, adjacent to an area of gastric mucosa.

No. 7.—Megevaud and Dunant,¹⁹ 1922. Male, aged twenty-eight years, intestinal hæmorrhages since early childhood, with many attacks of abdominal pain. On June 21

and 22, 1918, a large amount of blood was passed by bowels. At 9:30 P.M. the patient was almost in collapse. There was no definite diagnosis but duodenal ulcer was considered probable. *Operation*.—No ulcer of the stomach or duodenum was found. There was no blood in the small intestines but a large amount was found in the colon. A Meckel's diverticulum five and one-half centimetres long was found about forty centimetres above the ileocecal valve. The diverticulum was excised, with recovery. The diverticulum was lined for the most part with gastric mucosa; at junction of gastric with intestinal mucosa was a peptic ulcer with erosion of vessels.

No. 8.—Brasser,²⁰ 1924. Male, aged fifteen years. Pain in lower abdomen; ten days later repeated intestinal hæmorrhages. *Diagnosis*.—Intestinal polyp tumor or tumor of colon. *Operation*.—Colon filled with blood but source not found. Abdomen closed. Eight days later sudden development of peritonitis, with death. *Autopsy*.—Meckel's diverticulum with clubbed and attached to appendix. Perforation at base, with ulcer located at line of transition of gastric in intestinal mucosa.

No. 9.—Guibal,²¹ 1924. Male, aged fourteen years. Painless intestinal hæmorrhage recurring over a period of six months; later symptoms of right renal colic. *Diagnosis* not definite, but ileocecal tuberculosis suspected. *Operation*.—A Meckel's diverticulum seven centimetres long, with clubbed end; perforation two centimetres above its opening into the intestine, at a point of junction of intestinal and gastric mucosa. Resection of twenty centimetres of ileum, with recovery.

No. 10.—Humbert,²² 1924. Male, aged eleven months. Intestinal hæmorrhages at five and eight months. Present attack sudden onset with abdominal pain and other evidence of acute intra-abdominal disease. Became progressively worse. *Diagnosis*.—Perforative peritonitis, probably not of appendiceal origin, as most of the symptoms were in the median line and to the left. *Operation*.—Abdomen opened, with immediate escape of gas and pus. Bladder accidentally incised and sutured. Drainage was instituted and the wound closed. Death. *Autopsy* revealed a Meckel's diverticulum one by three centimetres with conical, free, distal end. There was a perforated ulcer at the exact junction of intestinal with gastric mucosa.

No. 11.—Jackson, R. H.,²³ 1924. Male, aged ten years. Recurring hæmorrhages and left-sided abdominal pain for four years. No diagnosis was arrived at, and operation was undertaken for the purpose of exploring for the source of the hæmorrhage. An indurated Meckel's diverticulum was found three by six centimetres, coming off from the ileum fifty centimetres above the ileocecal valve. Twelve centimetres of ileum, with the diverticulum, were resected, with recovery. An indurated ulcer was found at the junction of the ileum with the diverticulum, about four-fifths of the ulcer lying in the diverticulum. The specimen was lost in transit to the laboratory, hence no histological sections were made.

No. 12.—Abt and Strauss,²² 1925. Female, aged two years. Recurring hæmorrhages and slight abdominal pain for four months. Operation revealed a large inflammatory mass imbedded in the mesentery. Mass resected, with part of ileum; end-to-end anastomosis. In the mass was found an ulcerated Meckel's diverticulum, with remnants of gastric mucosa at apex, with recovery.

No. 13.—Abt and Strauss. Male, aged eleven months. Intestinal hæmorrhages for two months, with severe pain for a short time before operation. Exploration on account of bleeding. No diagnosis made. Meckel's diverticulum found two and one-half inches above ileocecal valve. Distal end infiltrated and attached to cæcum and appendix. It was filled with blood and there were several ulcers at the tip. Histology not reported.

No. 14.—Ulrich,²³ 1925. Male, aged eight years. On the morning of admission had three bloody stools but no pain. During the next three days, one or two bloody stools each day. On the fourth day became acutely ill, with fever, pain, constipation, and abdominal rigidity. No definite diagnosis. *Operation*.—Perforated Meckel's diverticulum two and one-half centimetres long, adherent to right side of pelvis by a strand which emanated from the tip. Excision of diverticulum, with death. *Histological*

HÆMORRHAGE FROM MECKEL'S DIVERTICULUM

Examination.—Lower portion of the diverticulum was lined with intestinal mucosa, above this was typical gastric mucosa.

No. 15.—Pascale,²⁴ 1925. Woman, aged forty-one years. Since seventeen years of age had suffered from abdominal pains and indigestion. After about eleven years the pain became definite in the para-umbilical region on the right side. One year later following a severe attack of pain there was a bloody stool. Other similar attacks occurred at long intervals. Up to this time the diagnosis had been recurring appendicitis. Pascale ruled this out, and made a diagnosis of ulcer of the small intestine. *Operation.*—There was found a Meckel's diverticulum two centimetres long, with free distal end, which was removed, with recovery. *Histological Examination.*—On opening the diverticulum a fecal concretion was found; also a cicatrized ulcer. Gastric mucosa was present. The findings indicated that there had been a round ulcer of the diverticulum which had healed spontaneously.

No. 16.—Stulz and Woringer,¹¹ 1926. Male, aged four years. Sudden onset with abdominal pain, vomiting, and intestinal hæmorrhage. Was seen on eighth day. *Probable Diagnosis.*—Intussusception. *Operation.*—Meckel's diverticulum size of an adult thumb, with perforation at base. Mesenteric vessels leading to diverticulum were ligated; the diverticulum was fixed to the parietal peritoneum and allowed to become gangrenous, when it was snipped off. No sections of the diverticulum were possible. Death from secondary peritonitis.

No. 17.—Stulz and Woringer. Male, aged eleven months. Was under observation twelve days when child died. *Autopsy.*—Meckel's diverticulum size of a child's thumb fixed to peritoneum in right paravesical region by a fibrous band. There was a small peridiverticular abscess, and a perforated ulcer with clean-cut border at the margin of the intestinal and diverticular mucosa. No histological sections could be made.

No. 18.—Mayo and Johnson,³³ 1926. Male, aged fifteen years. Appendicitis, followed by two intestinal hæmorrhages occurred when three years of age. At age of twelve had two attacks of appendicitis within three months. The ruptured appendix was removed. Three weeks later had intestinal hæmorrhage. Repeated hæmorrhages with epigastric pain continued at intervals for the next three years. Abdominal exploration, no pre-operative diagnosis. Exploration of stomach, duodenum, pancreas, gall-bladder, liver and colon was negative. Beginning at the duodenojejunal angle, the small intestine was examined inch by inch, to a site forty-five centimetres above the ileocecal valve, where an inflamed, œdematous Meckel's diverticulum was found. It was profusely supplied with large blood-vessels; it was resected. The patient recovered. No pathological report is submitted. The presence of ulcer is not mentioned.

No. 19.—Kleinschmidt,²⁵ 1927. Male, aged fifteen years; for one and one-half years pain in right lower abdomen. Nine months before admission, severe intestinal hæmorrhage with pain and vomiting. On admission diagnosis of gastric ulcer was made and he was placed on ulcer treatment for nineteen days, when sudden violent pain in the right lower abdomen suggested acute appendicitis. *Operation.*—There was found a Meckel's diverticulum three by six centimetres attached to the umbilicus. The diverticulum perforated near its attachment to the ileum. The diverticulum was resected, with recovery. The diverticulum was entirely lined with gastric mucosa.

No. 20.—McCalla,²⁰ 1927. Male, aged three years and ten months. Recurring hæmorrhages since eleven months of age with some abdominal pain. For four months has been well except for slight abdominal pain. On August 14 felt unusually well, but during the night had severe abdominal pain, sank rapidly and died. Autopsy revealed a Meckel's diverticulum with perforation at the base. The ulcer was located at a point where the intestinal and gastric mucosa merged.

No. 21.—Jackson, A. S.,³⁴ 1927. Male, aged fourteen years. Severe generalized abdominal pain followed three days later by intestinal hæmorrhage. He was seen on the fourth day by Dr. E. A. Ketterer, the same physician who had about ten years before sent a patient with intestinal hæmorrhage to Dr. R. H. Jackson, which proved

to be due to a bleeding ulcer of Meckel's diverticulum. This physician, from his observation of the case of R. H. Jackson, made a diagnosis in this case of bleeding of Meckel's diverticulum. Further hæmorrhages continued until the patient was exsanguinated, and required several transfusions before operation. Operation revealed a Meckel's diverticulum three by eight centimetres; distal end was free, and presented a puckered appearance. The diverticulum was excised, with recovery. Pathological examination revealed an ulcer and the diverticulum showed areas of gastric mucosa.

No. 22.—Meiss,²⁷ 1928. Child, aged two years. Sudden severe abdominal pain of few minutes' duration but recurring frequently. Twenty-four hours before admission had very large bloody stool with little or no pain. No diagnosis was made further than intestinal hæmorrhage of undetermined origin. *Operation*.—There was a Meckel's diverticulum three centimetres long with tip infiltrated and adherent to ileum, into which it had perforated. The diverticulum was excised, with recovery. *Histological Examination*.—Intestinal mucosa was found in the portion of the diverticulum near the ileum, with sudden transition to gastric mucosa, which lined the greater part of the diverticulum.

No. 23.—Peterman and Seegar,²⁸ 1928. Male, aged six years. Boy was struck in groin by wagon tongue. There was pain and vomiting for two days, also marked anæmia. *Diagnosis*.—Acute appendicitis. *Operation*.—Much blood in abdominal cavity. Drainage instituted and wound closed. Some time later there were repeated hæmorrhages from the bowel associated with pain and tenderness about the umbilicus. *Diagnosis*.—Bleeding from Meckel's diverticulum. *Operation*.—A Meckel's diverticulum was found forty-five centimetres from the ileocecal valve. It was four centimetres long, with the tip attached to the ileum eleven and one-half centimetres above the point of origin of the diverticulum. An ulcer had perforated from the tip into the ileum. Twenty-eight centimetres of ileum with the diverticulum were resected, with recovery. The tip was lined with gastric mucosa. Two ulcers were also found in the ileum and one in the base of the diverticulum.

No. 24.—Winkelbauer,²⁹ 1929. Male, aged two years. Abdominal pain followed in a short time by 200 cubic centimetres of bright red blood. Abdomen soft and only slightly tender to pressure on right side. Probable diagnosis; intussusception. *Operation*.—No intussusception found. There was found a Meckel's diverticulum three centimetres long with œdematous walls. At one spot was a more notable hardening, and a bleeding ulcer was suspected. The diverticulum was excised. Recovery. On opening the diverticulum was a shallow ulcer in the border of the ileum separated by a narrow zone from an island of gastric mucosa.

No. 25.—Winkelbauer. Male, aged nineteen months. A few hours before coming to a physician had been taken ill with abdominal pain and vomiting, and a passage by bowels of about one-eighth of a litre of blood. The abdomen was soft and not tender. He had a second intestinal hæmorrhage. Intussusception was suspected. *Operation*.—There was found a Meckel's diverticulum from the apex of which a strand extended toward the small intestine where it was fixed. A loop of small intestine was incarcerated by the strand. The colon was filled with blood but the cause of the hæmorrhage was not determined; the incarcerated intestine was freed and the abdomen was closed. Two months later the patient returned because of recurrence of intestinal hæmorrhages. *Operation*.—In the middle of the ileum there was an invagination of the diverticulum fixed by adhesions. It contained an ulcer. The diverticulum was extirpated, with recovery. *Histological Examination*.—The preparation showed a peptic ulcer with erosion of a branch of an artery. In the sections examined neither gastric mucosa nor pancreas tissue could be determined.

No. 26.—Schwarz and Daly,³⁰ 1929. Male, aged eight years. Patient suffered from intestinal hæmorrhages, abdominal pain and cramps, for several days. Severe anæmia was noted. He was kept under observation for three days, and a diagnosis of bleeding from ulcer of Meckel's diverticulum was made. Operation revealed an elongated

Meckel's diverticulum, which was removed. Recovery. The diverticulum contained an ulcer which had eroded a large artery. No histological studies are presented.

No. 27.—Smith and Hill,³⁷ 1928. Male, aged fourteen months. Intestinal hæmorrhage was followed four days later by vomiting, abdominal pain, visible peristalsis, and abdominal distension, and a mass was detected in right lower abdomen. *Diagnosis*.—Intestinal obstruction of uncertain origin. *Operation*.—Meckel's diverticulum four centimetres in length, perforated and gangrenous at distal end. Secondary obstruction from adhesions. Resected. Recovery. No pathological report.

No. 28.—Aschner and Karelitz,³⁸ 1930. Female, aged fifteen months. Pallor, vomiting, fever, for five days; followed by blood in stool and a tender mass in right lower abdomen. Was sent to hospital with diagnosis of Meckel's diverticulum. At hospital it was thought that the condition was intussusception. *Operation*.—No intussusception. An inflamed diverticulum four centimetres long was found, attached by a fibrous strand to the umbilicus. A loop of intestine passed under this and several loops were matted together by adhesions. The diverticulum was freed from the umbilicus and the adherent intestines were freed. The wound was closed. *Secondary Operation*.—Sixteen days later for removal of the diverticulum. The diverticulum was lined throughout with gastric mucosa, and there was a chronic penetrating ulcer situated in mucosa, of intestinal type, but immediately adjoining mucosa of gastric type.

No. 29.—Aschner and Karelitz. Male, aged twenty-six months. Repeated attacks of intestinal hæmorrhage for nine months. The later attacks were associated with pain. *Diagnosis*.—Recurring intussusception. *Operation*.—(Dr. A. V. Moschowitz.) A Meckel's diverticulum inflamed and indurated, was found eighteen inches above ileocecal valve. It was excised and patient recovered. Histological examination showed an ulcer at the neck of the diverticulum at the junction of intestinal and gastric types of mucosa.

No. 30.—Fevre, Patel and Lapart,³⁹ 1930. Male, aged five months. The day before he was seen by a physician had several black stools but was not otherwise ill. On the following morning he was seized with sudden violent abdominal pain and vomiting, accompanied by fever and another bloody stool. *Diagnosis*.—Intussusception. *Operation*.—No intussusception found. There was a short thick Meckel's diverticulum three centimetres long adherent to the ileum with a perforated ulcer at the base. Diverticulum removed, with recovery. *Histological Examination*.—The perforation was located in an ulcer on the intestinal mucosa immediately below an area of gastric mucosa.

No. 31.—von Haberer,⁴⁰ 1930. Male, aged thirteen years, appendectomy for colicky pains about umbilicus. Relief for four weeks then return of pain for two months; further periods of relief, then return of pain. For seven weeks previous to admission had several tarry stools, and became very anæmic. Ileocecal tuberculosis was suspected. *Operation*.—Massive adhesions about descending colon and bladder, and in the mass was a hard tumor, on freeing which a long perforated Meckel's diverticulum was found. The diverticulum, together with the cæcum and 1.3 centimetres of ileum resected, with recovery. *Histological Report*.—Base of the diverticulum was lined with small intestinal mucosa, upper part showed gastric mucosa. The perforated ulcer was located at the boundary between the gastric and intestinal mucosa.

No. 32.—Greenwald and Steiner,⁴¹ 1931. Male, aged fifteen weeks. Patient had two large tarry stools associated with pain and restlessness. Two weeks later had sudden attack of abdominal pain, vomiting and fever. Fluoroscopical examination revealed a column of air between liver and diaphragm. *Diagnosis*.—Perforated Meckel's diverticulum. *Operation*.—Meckel's diverticulum size of hazelnut was found, with perforation near base. The diverticulum was excised, with death resulting. The diverticulum showed a punched-out perforated ulcer near the base. The mucosa showed areas of gastric mucosa.

No. 33.—Author's case. Male, aged nine months; painless intestinal hæmorrhage for about thirty-two hours. Source of bleeding not ascertained: At operation a Meckel's diverticulum was found thirty-five centimetres above ileocecal valve. It was approxi-

mately six centimetres long, and the tip was free and nodular. It was excised, with recovery. *Histological Examination*.—Peptic ulcer with erosion of a vessel at margin of area of gastric and intestinal mucosa.

NOTE.—In the New England Journal of Medicine, vol. ccvi, No. 16, April 21, 1932, appeared a paper by Henry W. Hudson, Jr., and Lewis Henry Koplik, entitled "Meckel's Diverticulum in Children; A Clinical and Pathological Study," with a report of thirty-two cases from the Children's and Infant's Hospital of Boston.

This paper appeared just after our paper was completed, and too late for inclusion of any of its cases in our analysis.

We feel that reference should be made to this paper, since, in the thirty-two cases reported, hæmorrhage was the chief symptom in seven instances and was noted in ten other instances.

This is a vastly larger number than has ever been observed in any other clinic.

BIBLIOGRAPHY

- ¹ Deetz, E.: Perforationsperitonitis von einem Darmdivertikel mit Margenschleimhautbau ausgehend. Ein Beitrag zur Erklärung der Ectopia Ventriculi. Deutsch. Ztschr. f. Chirurg., B. 88, pp. 482-493, 1907.
- ² Christie, Amos: Meckel's Diverticulum, a Pathological Study of Sixty-three Cases. Amer. Jour. Dis. Child., vol. xiii, No. 3, pp. 544-553.
- ³ Meyer, A.: A Contribution to the Knowledge of Inflammation of Meckel's Diverticulum. Deutsch. Ztschr. f. Chirurg., B. 93, pp. 346-366, 1912.
- ⁴ Wellington, J. R.: Meckel's Diverticulum. Surg. Gynec., and Obst., vol. xvi, pp. 74-78, 1913.
- ⁵ Kelly, and Hurdon: The Vermiform Appendix and Its Diseases. W. B. Saunders Co., p. 599, 1905.
- ⁶ Adami, and Nicholls: The Principles of Pathology. Lea & Febiger, vol. ii, pp. 427-428, 1911.
- ⁷ Cullen, Thomas S.: The Umbilicus and Its Diseases. W. B. Saunders Co., p. 160, 1916.
- ⁸ Schaetz, George: Beitr. z. path. Anatomy u. z. allg. pathol., vol. lxxiv, Nos. 1, 2, 3.
- ⁹ Bookman, Milton R.: Carcinoma in the Duodenum. ANNALS OF SURGERY, vol. xcv, No. 3, pp. 464-467, March, 1932.
- ¹⁰ Tillmanns, H.: Ueber angeboren prolaps von Margenschleimhaut durch den Nabelring (ectopia ventriculi) und uber sonstige Geschwulste and fisteln des Nabels. Deutsch. Ztschr. f. Chirurg., vol. xvii, p. 161, 1882-1883.
- ¹¹ Stulz, E., and Woringer, P.: Peptic Ulcer of Meckel's Diverticulum. ANNALS OF SURGERY, vol. lxxxiii, No. 4, pp. 470-479, April, 1926.
- ¹² Hübschmann: Spät perforation eines Meckelschen divertikels nach trauma. Munchen. med. Wchnschr., No. 37, pp. 2051-53, September 16, 1913.
- ¹³ Callender, G. R.: Gastric Glands in Meckel's Diverticulum. Amer. Jour. of Med. Sci., vol. cl, No. 1, pp. 72-79, July, 1915.
- ¹⁴ Griffith, J. P. Crozier: Diseases Connected with Meckel's Diverticulum, with Special Reference to Diverticulitis. Trans. Amer. Pediatric Society, pp. 211-222, May, 1914.
- ¹⁵ Hildebrandt: Ueber die Entzündung des Meckelschen Divertikels. Charite Annalen, vol. xxx, pp. 442-451, Berlin, 1905.
- ¹⁶ Hilgenreiner, Heinrich: Entzündung und Gangran des Meckel's chen Divertikels. Beitr. z. klin. Chir., vol. xl, pp. 99-135, Tübingen, 1903.
- ¹⁷ Müller, Paul: Ueber das Ulcus pepticum (perforans) des Meckel'schen Divertikels und seine Verwandtschaft mit dem Ulcus ventriculi. Beitr. z. klin. Chir., vol. cxv, pp. 560-577, Tübingen, 1919.
- ¹⁸ Meulengracht, E.: Ein teilweise mit Magenschleimhaut bekleidetes und den Sitz eines Ulcus pepticum bildendes Meckelsches Divertikel. Virchow's Arch. f. Pathol. Anat., etc., vol. ccxxv, pp. 125-128, Berlin, 1918-1919.

HÆMORRHAGE FROM MECKEL'S DIVERTICULUM

- ¹⁰ Megevaud, E. C., and Dunant, R.: *Ulcere peptique du diverticule de Meckel; hemorragies intestinales.* Rev. de chir., vol. lx, pp. 536-552, 1922.
- ²⁰ Brasser, Alfred: *Ulcus pepticum perforans des Meckel'schen Divertikels.* Zentralbl. f. Chir., vol. li, pp. 2423-2427, Leipzig, 1924.
- ²¹ Guibal, L.: *Ulcere peptique d'un diverticule de Meckel provoquant des hemorragies intestinales profuses; operation; guerison.* Bull. et mem. Soc. nat. de chir., vol. i, pp. 349-355, 1924.
- ²² Humbert, J.: *L'ulcere peptique du diverticule de Meckel.* Paris Thesis, No. 395, p. 108, 1924.
- ²³ Ulrich, G. R.: *Et Tilfaelde af perforet Meckel's Diverticulum.* Ugesk. f. Laeger, vol. lxxxvii, pp. 664-666, 1925.
- ²⁴ Pascale, G.: *L'ulcera peptica del diverticolo di Meckel.* Riforma med., vol. xli, pp. 721-724, 1925.
- ²⁵ Kleinschmidt, Karl: *Das Ulcus pepticum des Meckel'schen Divertikels.* Beitr. z. klin. Chir., vol. cxxxviii, pp. 715-720, Berlin and Vienna, 1926-1927.
- ²⁶ McCalla, A. I.: *Case of Perforated Peptic Ulcer of Meckel's Diverticulum.* Canad. Med. Assn. Jour., vol. xvii, pp. 79-81, 1927.
- ²⁷ Meiss, W. C.: *Hevige Darmbloeding door een Ulcus in een Divertikel van Meckel.* Nederl. Tijdschr. v. Geneesk., vol. lxxii, pp. 4020-4022, Haarlem, 1928.
- ²⁸ Winkelbauer, A.: *Ueber die chirurgischen Erkrankungen des Meckel'schen Divertikels.* Wien. klin. Wchschr., vol. xlii, pp. 989-993.
- ²⁹ Febre, M., Patel, and Lepart: *Ulcères perforés du diverticule de Meckel.* Bull. et mem. Soc. nat. de chir., vol. lvi, pp. 756-767, 1930.
- ³⁰ von Haberer, H.: *Beobachtungen über Komplikationen von seiten des Meckel'schen Divertikels.* Deutsch. Ztschr. f. Chir., vol. ccxxv, pp. 131-144, Leipzig, 1930.
- ³¹ Jackson, R. H.: *Hæmorrhagic Ulcer of Meckel's Diverticulum.* ANNALS OF SURGERY, vol. lxxx, No. 2, August, 1924.
- ³² Abt, I. A., and Strauss, A. A.: *Meckel's Diverticulum as a Cause of Intestinal Hæmorrhage.* Jour. of Amer. Med. Assn., vol. lxxxvii, No. 13, pp. 991-996, September 25, 1926.
- ³³ Mayo, W. J., and Johnson, A. C.: *Meckel's Diverticulum.* Surg. Clin. N. Amer., The Mayo Clinic Number, October, 1926.
- ³⁴ Jackson, A. S.: *Ulcer of Meckel's Diverticulum as a Cause of Intestinal Hæmorrhage.* ANNALS OF SURGERY, vol. lxxxv, No. 2, February, 1927.
- ³⁵ Peterman, M. G., and Seedgar, S. J.: *Meckel's Diverticulum with Hæmorrhage.* Amer. Jour. Dis. Chil., vol. xxxvi, No. 3, September, 1928.
- ³⁶ Schwarz, E. G., and Daly, J.: *Meckel's Diverticulum Associated with Severe Hæmorrhage.* Jour. Amer. Med. Assn., vol. xciii, No. 19, p. 1468, November 9, 1929.
- ³⁷ Smith, J. T., and Hill, O. W.: *An Interesting Case of Meckel's Diverticulum Associated with Intestinal Hæmorrhage, Diverticulitis, Intestinal Obstruction, and Recovery.* Arch. Pediat., vol. xlvi, No. 8, August, 1929.
- ³⁸ Aschner and Karelitz: *Peptic Ulcer of Meckel's Diverticulum and Ileum.* ANNALS OF SURGERY, vol. xci, No. 4, April, 1930.
- ³⁹ Fevre, M., Patel, and Lepart: *Ulcères perforés du diverticule de Meckel.* Bull. et mem. Soc. nat. de chir., vol. lvi, pp. 756-767, 1930.
- ⁴⁰ von Haberer, H.: *Beobachtungen über Komplikationen von seiten des Meckelschen Divertikels.* Deutsch. Ztschr. f. Chir., vol. ccxxv, pp. 131-144, Leipzig, 1930.
- ⁴¹ Greenwald, H. M., and Steiner, M.: *Meckel's Diverticulum in Infancy and Childhood.* Amer. Jour. Dis. Chil., vol. xlii, No. 5, November, 1931.
- ⁴² Moll, H. H.: *Brit. Jour. Surg.*, vol. xiv, p. 176, 1926.
- ⁴³ Tisdall, Frederick F.: *An Unusual Meckel's Diverticulum as a Cause of Intestinal Hæmorrhage.* Amer. Jour. Dis. Chil., vol. xxxvi, No. 6, December, 1928.

DISCUSSION.—DR. J. M. T. FINNEY (Baltimore, Md.) said that his interest in Meckel's diverticulum began early in his surgical career: The first case of supposed appendicitis that he operated upon turned out to be a perforated Meckel's diverticulum. He reported a case in which, while they were not able positively to demonstrate the presence of gastric mucosa, the clinical history and findings strongly suggested a Meckel's diverticulum as the origin of the trouble. The tumor was about the size and shape of a Bartlett pear, situated about three feet from the ileocecal valve. It was largely cystic but contained an area which was definitely myomatous and which was continuous with the lumen of the bowel. There was considerable clotted blood surrounding the myoma, and here and there areas of scar tissue in the cyst wall. The cyst contained thin chocolate-colored fluid. The inner surface of the cyst wall was ulcerated, with areas of aberrant mucosa scattered here and there, but no gastric mucosa could be demonstrated. The pathological report was myoma of the ileum accompanied by cystic formation.

The patient was a man twenty-nine years of age with a history of three or four years' duration of recurrent hæmorrhages from the bowel. These were at times quite severe and would come on without warning. The blood was of rather tarry consistency, suggesting that the origin of the hæmorrhages was some distance up. There was little or no gastric disturbance. Slight indigestion was noticed from time to time, but no pain and no loss of weight. He had been actively at work right along. He had a congenital club-foot.

He had visited a number of clinics and had been seen by a good many physicians. In one of the well-known clinics, he spent four or five weeks on a Sippy diet to relieve his hæmorrhage. He had several transfusions, and was finally operated upon. The tentative diagnosis was "bleeding duodenal ulcer." Although no ulcer was found at the time of operation, a gastroenterostomy was done, hoping thereby to relieve the hæmorrhage. Following the operation, no improvement was noted. Finally, he came into our hands. After a careful and prolonged study, we were unable to make a positive diagnosis.

An incision was made in the upper part of the right rectus. Careful inspection of the abdominal cavity revealed no ulcer or scar. The gastroenterostomy opening was patent and there was no evidence of marginal ulcer. He had a definitely thickened appendix. This was removed. A thorough search of the abdomen was then made and a mass about the size of a small fist found on the floor of the pelvis, quite adherent to the bladder and large intestine. It was evident that another incision would have to be made in order to remove the growth. This was deferred to a second sitting. After three weeks, the abdomen was reopened in the mid-line below the umbilicus; the exposed tumor could be separated quite satisfactorily from the attached bladder and sigmoid, and out of the abdomen, and was resected.

The patient made a prompt and satisfactory recovery.

DR. EMIL GOETSCH (Brooklyn, N. Y.) referred to the case of a young man, nineteen years of age, who was admitted to the Bingham Hospital, Boston, because of intestinal obstruction. He had been operated on six years previously in Ireland for what was called an "abdominal abscess." The reporter presented three illustrations to show the pathology of the instances of aberrant gastric mucosa in Meckel's diverticulum. In the first one is a diagrammatic representation of the condition found at operation. A scar was present above the umbilicus as a result of the former operation. A mass of small intestine was found hanging over a band attached to the abdominal scar and continuous with Meckel's diverticulum, the whole cord being five or six inches in length. There was a small bowel obstruction. The cord was excised together with the diverticulum and the patient made an uneventful recovery. The diverticulum was opened. In the distal one-fourth of the diverticulum was a very thick mucosa which had a granular and papillary appearance, and a proximal thin mucosa of the type of the ileum.

Subsequent histological examination at the point representing a section through the transition zone was a thick gastric mucosa with large branching papillary glands and

HÆMORRHAGE FROM MECKEL'S DIVERTICULUM

the proximal ileal type of mucosa with the simple glands characteristic of the ileum. A high-power drawing of an actual section showed papillary columnar epithelium on the surface and long, deep glandular tubules reaching down to the submucosa, typical of the fundus area of the stomach.

On further magnification the surface type of goblet mucus cell, and in the neck of these glands, which are typical of the fundus of the stomach, are the two types of glandular epithelium, the chief or peptic cells bordering the lumen and the large parietal cells containing the typical acidophilic granules. Next we have a highly magnified section of the gastric mucosa showing eosinophilic granules in the parietal cells, and the chief cells with their basophilic secretion granules, typical of the gastric mucous membrane. The proximal mucosa resembles that of the duodenum except that there are no Brunner's glands. Further sections, in the oil immersion, high magnification, show the parietal cells, the large clear cells of the acid type containing eosinophilic granules, and the basophilic zymogenic secretion granules of the chief cells (acid-fuchsin methyl green method).

It was shown in the report to which I have referred and which was published in the Johns Hopkins Bulletin in 1919 that aberrant gastric mucosa, typical of the fundus area of the stomach, may occur in Meckel's diverticulum. Doctor Mason has called attention to the occurrence of ulceration, with consequent hæmorrhage, in this foreign tissue. In Doctor Goetsch's case such an ulceration subsequently perforated and gave rise to the abscess for which the man was operated upon six years previous to the exploration for intestinal obstruction. At this second operation, a Meckel's diverticulum with the curious findings described was removed.

DR. HUBERT A. ROYSTER (Raleigh, N. C.) reported the case of a boy about ten years of age who was seized with a sudden abdominal pain followed by hæmorrhage from the bowel. He had a very free discharge from both ears, which showed on examination diphtheritic organisms. Upon using the diphtheria antitoxin, this hæmorrhage ceased. He went away to another city for the treatment of his ears and was not seen by Doctor Royster for two months, when examination showed a nodule about the size of a thumb-nail in the lower abdominal region in the median line and one in the upper, which was a ventral hernia with omentum. The question was, that if the one above was a hernia, what was the other one below? In a few days the mass below began to enlarge and perforated through the abdominal wall before operation was allowed. At operation Doctor Royster opened the area below and drained it and a month later went in and explored and found a perforated Meckel's diverticulum showing gastric mucosa.

DR. VERNON C. DAVID (Chicago) agreed with Doctor Finney that patients, especially children, who are suspected to be bleeding from Meckel's diverticula should be carefully regarded from the standpoint of hæmorrhage from more common and less popularly discussed sources, papillomata, adenomata, and mild, low-grade ulcerative colitis. These things are rather common in children and may be without any symptoms whatsoever except the bleeding. He had happened to have seen quite a few instances of such conditions, some of whom had diagnoses of diverticulum of Meckel. He added the report of a case, a man thirty years of age, who was received into the hospital because of two or three very severe hæmorrhages which had reduced his hæmoglobin to thirty. The night of his entrance to the hospital, he began to have abdominal pain and after a transfusion because of very severe anæmia, which was increasing, was operated upon because of the pain, rigidity, temperature, and vomiting. No lesion was found in the duodenum or stomach. Deep in the abdomen was a tumor which was a Meckel's diverticulum in its outline, position, and shape, which had a perforation about the size of a dime. There were several nodules around it about the size of a pea and some enlarged mesentery glands which were hard; apparently the lesion was a perforated carcinomatous ulcer of Meckel's diverticulum. The specimen was lost so that

no microscopical examination was made—a bowel resection was done from which an uneventful recovery followed.

DR. EDWIN BEER (New York City) remarked that these ulcerations in Meckel's diverticulum may throw some light on secondary ulcerations following gastroenterostomy. He had seen a number of cases of aberrant gastric mucosa in Meckel's diverticulum. The literature of this subject, as well as the specimens examined pathologically, show the ulcer always at the periphery of the gastric mucosa; in other words, it is always at the place where the two mucosæ come together.

Is it an ulceration of ileac mucosa or is it an ulceration of the gastric mucosa? If it were an ulceration of the gastric mucosa, one would expect much more extensive destruction of the gastric mucosa, suggesting that it is probably an ulceration of the ileac mucosa. Perhaps secondary ulcers after gastrojejunostomy' owe their origin to similar or analogous conditions. Misplaced gastric mucosa in the navel also is liable to produce a somewhat similar ulceration.

CLINICAL ASPECTS AND TREATMENT OF PRIMARY LYMPHOSARCOMA OF THE STOMACH AND INTESTINES

BY DAVID CHEEVER, M.D.

OF BOSTON, MASS.

MALIGNANT neoplasms derived from other tissues than epithelium and affecting the gastro-intestinal tract are, it is true, relatively uncommon, but their occasional occurrence and serious prognosis warrant their study with a view to standardizing so far as possible the methods of treatment. Data from the literature are in a chaotic state, largely because of confusion and looseness in the classification of lesions, whose clinical courses vary greatly according to their type, so that the symptomatology, prognosis and reaction to treatment of one case may have but little resemblance to another, though they are designated by the same name. On account of the rarity of these conditions the experience of any one observer is limited, and the literature therefore consists largely of the recital of single cases, and makes but dull reading.

These tumors, usually loosely included under the term sarcoma, comprise a group sharply demarked in theory from the recognized epithelial tumors, but nevertheless not always clearly defined, since the embryonal origin of the cells of some, such as the endotheliomas, are still the subject of dispute. Moreover, in the case of certain small round-cell tumors, competent pathologists may differ about the classification as between carcinoma or sarcoma. Any of the mature mesoblastic tissues represented in the structure of the gastro-intestinal tract may be the seat of a malignant tumor, which then may be appropriately designated as fibro-, angio-, lipo-, myo-, myxo- and lymphosarcoma, respectively, according to the differentiated type of cell from which it springs. The designation of the tumor according to the morphology of its cells—whether composed of spindle, round or giant cells is not of much significance, since each of these types may occur in tumors springing from any of the mesoblastic tissues; on the other hand, it will be understood that the study of the cellular morphology is necessary for histological diagnosis.

According to Ewing,¹ sarcomas of the gastro-intestinal tract are of three chief groups: (1) Spindle-cell myosarcoma, which are likely to be bulky, more or less pedunculated growths, projecting either within the lumen of the viscus or into the peritoneal cavity, non-infiltrating, late in metastasizing, and apt to become cystic when growth has out-stripped the blood supply; (2) a miscellaneous group of round-cell or mixed-cell alveolar sarcomas, rare and not deserving of classification as a separate variety; (3) lymphosarcoma, which constitutes by far the most numerous and important group, and which requires most careful analysis, on account of the very numerous conditions

which cause hyperplasia of lymphoid tissue. Ewing states that tumors of lymphoid tissue may arise from any of its three normal components: lymphocytes, reticulum and endothelium. Lymphocytic hyperplasia gives rise to a lymphocytoma, which may be due to some irritant, bacterial or otherwise, especially the tubercle bacillus (simple or tuberculous lymphoma), or may be a part of the clinical syndrome known as lymphatic leukemia or pseudo-leukemia, or may be an independent, locally arising tumor having all the characteristics of malignancy—a true malignant lymphocytoma. Reticulum cells undergoing hyperplasia may form tumors which are a local manifestation of myeloid leukemia, or Hodgkin's disease, or may constitute an independent, locally arising malignant tumor which may be designated as large round-cell lymphosarcoma; finally, endothelial cells of lymphoid tissue may proliferate and cause the endothelial hyperplasia of tuberculosis, or a true tumor growth designated as endothelioma. When it is realized that many observers believe that Hodgkin's disease is due to an infection, probably with the tubercle bacillus; that apparently true lymphocytomas have been described in the course of the disease, and that on the other hand in patients with lymphocytoma an excess of lymphocytes similar in all respects to the tumor-cells has appeared in the blood, thus simulating leukemia, it will be realized how difficult and confused is the classification. Mallory² prefers to simplify matters by using the term lymphoblastoma to include all lesions variously spoken of as lymphocytoma, lymphoma, lymphosarcoma, pseudo-leukemia, lymphatic leukemia and Hodgkin's disease, believing that these are but different manifestations of the same underlying process. He defines the lymphoblastoma as a tumor of mesenchymal origin of which the cells tend to differentiate into lymphocytes—the type cell is the lymphoblast, which occurs abundantly in the germinative centres in the lymph nodules of lymph-nodes, tonsils, gastro-intestinal tract and spleen. Minot and Isaacs,³ after referring to the utter confusion in the classification of diseases which have progressive enlargement of the lymphoid tissues as their most prominent feature, suggest the wisdom of recognizing four types depending on age incidence, clinical features, blood picture and pathological histology, as follows: (1) lymphatic leukemia; (2) pseudo- or aleukemic lymphatic leukemia; (3) Hodgkin's disease; (4) lymphoblastoma, having a distinct tendency to invade tissues, to involve tonsils, gastro-intestinal tract and serous membranes, and showing the multiplication of reticulum tissues and lymphoid cells usually called lymphosarcoma.

Whatever the inter-relation of these conditions, and the embryonal or adult origin of their characteristic cells, certain it is that a malignant tumor of lymphoid tissue may appear as an original focus in the gastro-intestinal tract, invade and destroy the structure in which it arises, spread by permeation and by lymphatic and blood metastasis, without the accompaniment of a blood dyscrasia such as lymphatic leukemia, and without the involvement of other lymphoid structures as in pseudo-leukemia, general lymphomatosis or Hodgkin's disease. Such a primarily local, but ultimately invading and

metastasizing malignant tumor closely corresponds to carcinoma in its clinical course, and is theoretically as susceptible of cure by extirpation. It apparently differs from carcinoma, as will be seen, in its markedly greater radio-sensitivity. In spite of theoretical objections the term "lymphosarcoma" conveniently designates these tumors.

This paper attempts to analyze the lymphosarcomas of the gastro-intestinal tract, excluding the rectum, which have been observed at the Peter Bent Brigham Hospital, Boston, since its foundation in 1913.* The diagnosis appears (with the variation "lymphoblastoma" or "malignant lymphoma") twenty-two times, but in four of these instances it is presumptive only, unconfirmed by biopsy or autopsy, while in a fifth a careful review of the histology has convinced the pathologist† that the tumor is in fact a small round-cell carcinoma. A sixth case is that of a fifty-one-year-old woman who died of septicæmia, whose stomach showed at autopsy a small, encapsulated, clinically benign nodule, whose histology was consistent with lymphosarcoma, and was so diagnosed. It seemed possible that a chance discovery at autopsy had revealed a malignant tumor at its early and still benign incipency. Further pathological study in the course of the preparation of this paper has led to the conclusion that it is a congenital tissue defect, of the type of lymphangioma, and non-malignant in character.

There remain, then, sixteen certified instances of primary lymphosarcoma of the stomach and intestines occurring in a hospital of 240 beds during nineteen years, in the course of which the total number of patients admitted for all tumors of the stomach and intestines was 976, giving a percentage of sarcomas of 1.63. Of the sixteen cases, nine were of the stomach; which among a total of 628 gastric tumors gives a percentage of lymphosarcoma of 1.4; seven were of the intestines, constituting 2 per cent. of all intestinal tumors. These figures correspond with most statements in the literature, that from 0.5 per cent. to 3 per cent. of all tumors of the stomach are sarcomas.⁴ Since the jejunum and especially the ileum are the most common situation of intestinal lymphosarcoma, which is much less common in the colon, and since carcinoma—while common in the colon—is exceedingly rare in the jejuno-ileum, it follows that lymphosarcoma of the small intestine, while rare, is by far the most common malignant tumor of that portion of the alimentary tract. Its frequency of incidence seems to increase with its distance from the stomach, being most uncommon in the duodenum and most frequent in the terminal ileum, where it naturally often involves the cæcum. In the Brigham Hospital series of seven cases, the disease was located in the jejunum in two instances, in the jejuno-ileum in two instances,

* For reference, the patients on whom this paper is based are numbered as follows in the Peter Bent Brigham Hospital records: S-3401; S-7322; S-13985; S-14572; S-14737; S-18055; S-21507; S-24969; S-24796; S-26974; S-31823; S-35035; S-38857; M-7428; M-17127; M-19182.

† Dr. S. Burt Wolbach has kindly reviewed the pathological material and his assistance is acknowledged by the writer.

in the distal ileum in two cases, and in the terminal ileum with involvement of the cæcum in one case. There was no instance of primary location in the colon.

Since the etiology is absolutely unknown, there is no object in rehearsing the familiar speculations regarding it. There was nothing to throw light on it derived from the study of this series.

Sex seemed to play no part in the incidence, there being four males and five females among the gastric cases, and four males and three females among the intestinal. The average age of all patients was 53.5 years; the youngest was thirty, the oldest seventy-five; the gastric cases averaged 56.2 years and the intestinal 50.1. This is apparently somewhat at variance with common experience, which indicates that sarcoma of the gastro-intestinal tract occurs at an age averaging at least ten years earlier. Balfour and McCann,⁵ reporting forty-five cases of sarcoma of the stomach, give the average age as forty-three years, and the preponderance of males over females as more than 2 to 1. Douglas,⁶ analyzing the literature, gives the average age as 41.6, and the sexes equally affected. Haggard⁷ quotes the average age as about 45.8 years and D'Aunoy and Zoeller⁸ tabulate 135 scattered cases whose ages average 36.7 years, with males almost twice as numerous as females. Sarcoma in general is widely recognized as much more prevalent in youth than is carcinoma, and the literature of sarcoma of the gastro-intestinal tract reveals the general opinion that it occurs on the average at a considerably earlier age than does carcinoma—a belief which does not seem to be sustained by the Brigham Hospital series.

Primary lymphosarcoma of the gastro-intestinal tract may have its origin in any nidus of lymphoid tissue, but appears most often to begin in a lymphoid follicle of the submucosa, whence it spreads by permeation along tissue spaces, and by infiltration through the various layers of the viscus, especially the muscularis. Since it does not at first involve the mucosa, ulceration is neither an early nor a characteristic occurrence, in sharp distinction from carcinoma. It has little tendency to penetrate the serosa until late in the disease, when perforation due to ischaemic necrosis is not uncommon. Since the tumor-cells lie in a scanty and very delicate reticulum, instead of being accompanied by the definite and important framework of connective-tissue stroma usually characterizing carcinoma, there is but little tendency for the neoplasm to contract and constrict the visceral lumen; rather does it seem to separate and thus weaken the fibres of the muscularis, or perhaps paralyzes the intrinsic neuromuscular mechanism, so that the viscus, especially if it be the intestine, appears dilated rather than contracted. The infiltrating lymphosarcoma under consideration does not develop the massive semipedunculated growths projecting either into the peritoneal or the visceral cavities. Metastasis may be by both blood- and lymph-streams—indeed, the involvement of regional lymph-nodes may be both early and extremely extensive, so that the masses of tumor-nodes in the mesentery or retroperitoneal tissues may quite overshadow the primary growth. Perusal of the literature

reveals much difference of opinion on this point, due usually to confusion of various other histological types with true lymphosarcoma, since it is well known that sarcoma in general, being built on an architecture of new blood-vessels, and perhaps devoid of lymphatics, is much more prone to metastasize by the blood than by the lymph currents. The primary lymph-node invasion is almost certainly by direct permeation rather than by free-cell metastasis. Blood metastases are necessarily through the portal system to the liver.

In gross appearance lymphosarcoma of the stomach cannot be differentiated from carcinoma, especially of the infiltrating "linitis plastica" type. There is diffuse thickening of the wall, of rubber-like consistency, usually without sharp delimitation, often purplish in color and contrasting with carcinoma simplex and malignant adeno-carcinoma by its softer consistency and lack of nodularity. The regional nodes, if involved, are large, smooth, elastic rather than hard, apt to be matted together and to form a tumor mass along the curvatures not separable from the parent tumor. The cut surface is of a uniform grayish or grayish-pink color, without gross evidence of structure. These gross characteristics are not sufficiently distinctive to permit certain differentiation from carcinoma. In the intestine the appearances are similar, the gut appearing enlarged and dilated, and the thickened rubber-like wall justifying the comparison with a piece of garden hose, an appearance quite different from the characteristic sharply delimited annular constricting appearance of the typical scirrhus adeno-carcinoma of the colon. In the cæcum, however, the gross appearances are again very similar to carcinoma. Microscopically, the tumors are composed of varying sizes of small or large lymphocytes, round, oval or polyhedral, with round, sharply outlined nucleus containing chromatin granules often peripherally distributed, scanty, basophilic cytoplasm, and delicate, sometimes scarcely demonstrable reticulum without definite structural arrangement, except for the appearance of thin-walled blood-vessels invaded by tumor-cells. Mitoses are usually numerous and often quite irregular. In some instances the differential diagnosis is scarcely to be made between lymphocytoma and a rapidly growing small round-cell carcinoma, unless secretory vacuoles in the cells of the latter can be demonstrated, and it is undoubted that many cases are reported as lymphosarcomas which are in reality carcinomas.

For reasons related no less to treatment than to the perfection of diagnostic science it would be highly desirable to be able to distinguish clinically between lymphosarcoma and carcinoma of the gastro-intestinal tract. All authorities agree that in the case of the stomach this is usually impossible. Cutler and Smith,⁹ reporting in 1922 two instances of lymphoblastoma of the stomach (which are included in the present Brigham Hospital series) state that differential diagnosis is impossible. D'Aunoy and Zoeller⁸ stated in 1930 that no case is on record where a clinical diagnosis was established. Pemberton¹⁰ says there is no record of a pre-operative diagnosis. Ruggles and Stone¹¹ say that X-ray findings are not sufficiently characteristic to permit of a specific diagnosis of lymphoblastoma. Balfour and McCann,⁵ report-

ing forty-five cases of proved sarcoma of the stomach occurring at The Mayo Clinic between January, 1908, and July, 1929, say that two were diagnosed before operation as sarcoma, and that in one of these the X-ray diagnosis of lymphosarcoma was correctly made. Presumably the other was some other form of sarcoma, such as myosarcoma, which, in contrast to lymphosarcoma, may present features permitting presumptive diagnosis.

Analysis of the symptoms of the patients in the Brigham Hospital series with involvement of the stomach showed that all complained of abdominal—usually epigastric, pain or discomfort, while some stressed such symptoms as anorexia, dyspnoea, and loss of weight, during a period varying from two weeks to two years before admission to the hospital. The average duration of symptoms was about seven months. Five of the nine cases complained of vomiting, but never of gross blood. Gastric analysis was done in five cases, all but one of which showed low or absent acid values. Occult blood was noted but once. No tarry stools were reported, but tests were positive for occult blood in four of the five cases in which the test was done. An epigastric tumor was felt in seven cases. X-ray examination was made in six instances, in four of which a filling defect was noted, and in two the crater of an ulcer. In one a 100 per cent. six-hour barium residue was reported, and in two a 20 per cent. and a 25 per cent. respectively. The tentative diagnosis was carcinoma in six, ulcer in one, malignancy of the abdomen in one. In all patients but one there was a mild to moderate secondary anaemia.

From this analysis it appears that the typical picture of a patient with lymphosarcoma of the stomach is an individual in the sixth decade, who has complained for seven months more or less of epigastric discomfort or pain, indigestion, moderate loss of weight and strength, and often vomiting. Examination shows an epigastric tumor and moderate anaemia; X-ray shows a filling defect with or without stasis, sometimes with a crater. Gastric analysis shows usually a low or absent hydrochloric acid and occasionally traces of blood. The stools usually show occult blood. It cannot be denied that this description fits perfectly a typical case of gastric carcinoma. Holmes, Dresser, and Camp¹² report X-ray studies of eight cases of lymphoblastoma of the stomach observed at the Massachusetts General Hospital, of which five appear to be true primary lymphosarcoma of the type now under consideration. No correct diagnosis was made in these cases and the authors conclude that the X-ray appearances do not differ from carcinoma except that peristalsis does not seem to be interfered with so much.

Analysis of the symptomatology of the seven cases of lymphosarcoma of the intestine constituting the Brigham Hospital series indicates that the duration of symptoms before admission varied from three weeks to seventeen months, with an average period of six and one-half months. The chief complaint in every case was abdominal pain, noted as epigastric in two instances; subsidiary complaints were vomiting and constipation, each in two instances. All these patients had lost from twenty to thirty pounds in weight. Stools

were noted as bloody by one patient, as tarry by one other. In every instance but one a tumor could be felt. In the four cases in which gastric analysis was done, free hydrochloric acid was absent. X-ray examination was made in six instances and was reported as follows: (1) residue in ileal loops; (2) 100 per cent. gastric residue and dilated duodenum; (3) rigidity of ileocecal valve and slight filling defect of the cæcum; (4) distension and obstruction of the small intestine; (5) filling defect of the sigmoid, not characteristic; (6) filling defect of the cæcum. As already noted, the nature of the infiltrating, non-constricting pathological process is such as not to lead to mechanical obstruction, so that such a picture as is given by the annular constricting carcinoma of the colon is not afforded. The filling defects noted are usually due to extrinsic pressure from large masses of metastatic glands. All patients but one showed a slight or moderate secondary anæmia.

The average clinical picture of a patient with lymphosarcoma of the intestine may be described as follows: a middle-aged or possibly much younger individual who for some months has complained of abdominal pain, situated anywhere but often epigastric, not definitely related to food or bowel action, sometimes but not necessarily accompanied by vomiting; an anæmia of secondary type with otherwise normal blood-picture; an insensitive mass anywhere in the abdomen, either occult or gross blood in the stools, and by X-ray either no striking appearance, or some evidence of dilated loops of small intestine with tendency to local stasis of the barium. An opaque enema would be likely to show a filling defect or deformity, if the disease were located in the colon.

The treatment of lymphosarcoma of the stomach or intestine, until the advent of therapeutic radiation, was exactly as in carcinoma—by an attempt at radical extirpation, and the results have been such as to inspire widespread pessimism. The classic case of Ruppert¹³ is widely quoted as the longest reported survival. His patient was a woman of fifty-eight years whose stomach was almost entirely involved in a primary lymphosarcoma accompanied by numerous nut-sized glands in both omenta; a subtotal gastrectomy was done and the patient was reported as living without evidence of recurrence fourteen and one-half years later. In making his report in 1912 Ruppert said that medical literature revealed but twelve radical operations for gastric lymphosarcoma, of which but seven made an operative recovery. The next longest survival, nine years, appears to be that of Finsterer (quoted by D'Aunoy and Zoeller.⁸ Balfour and McCann's series⁵ of forty-five cases of all types of sarcoma of the stomach afforded thirty-eight resections which survived operation; of those living when last heard from the average duration of life was five years, the longest nine years. This list, however, includes types other than lymphosarcoma. Isolated or small groups of cases are reported with survivals for lesser periods. Approximately the same results have followed surgical extirpation of the disease affecting the intestinal tract. Rankin and Chumley¹⁴ reporting in 1929 eighteen instances of lymphosarcoma of the colon including the rectum, noted

fifteen radical resections with four operative deaths; in five patients the disease recurred, and the remaining six were alive and well for four years and three years and various lesser periods. Weeden,¹⁵ reporting in 1929 twelve cases of lymphosarcoma of the intestine from the New York Hospital, noted six resections with three post-operative deaths, and survival periods of three and one-half years and one year for the two patients who were traced. Graves¹⁶ reports three cases resected with a maximum survival of three years without recurrence. Loria,¹⁷ in 1925, reviewed all reported cases and stated that the prognosis was very poor; he quotes Cornier and Fairbanks¹⁸ as analyzing ninety-six cases, with only one patient surviving as long as eight years. There are numerous isolated reports in the literature, which give the impression that on the whole the prognosis of the disease is even less favorable in the intestine than in the stomach.

The well-known radiosensitivity of undifferentiated cells in general and of lymphocytes and lymphoblasts in particular offers ground for hope that radiation may be effective in the relief of lymphosarcoma. Ruggles and Stone¹¹ say that X-ray therapy has a good deal to offer and on this account stress the desirability of diagnosis without exploratory operation, while regretfully admitting that it seems to be impossible. They present an analysis of eleven cases but do not mention the result of X-ray treatment. Matas, discussing a paper by Loria,¹⁷ stated in 1925 that deep X-ray therapy and radium have proved unavailing. Gunsett and Oberling¹⁹ report a remarkable case of a forty-eight-year-old man with an extensive annular neoplasm of the stomach, adherent to and involving the pancreas, extending upward on the lesser curvature to the cardia, with extensive glandular involvement along both curvatures—hopelessly inoperable. Biopsy of a gland showed lymphoblastic sarcoma; the cells were round or polyhedral with large nucleus containing one or two nucleoli and a delicate chromatin network, cytoplasm staining pink with eosin; mitoses were frequent and often irregular in type. The patient was given X-ray therapy in seventeen sessions during three weeks and at the end of five years was living and without symptoms if he avoided indigestible food; X-ray examination then showed that most of the stomach seemed to have disappeared! Strauss²⁰ reports the instance of a man of sixty-two with an inoperable tumor of the duodenum; biopsy showed lymphosarcoma. He received deep X-ray therapy and two years later had gained forty pounds, was in excellent health and showed no evidence of recurrence. Freeman²¹ reports a striking case of a man sixty years of age upon whom he performed resection of the stomach—the lines of section passing through tumor tissue. The pathological diagnosis was variously reported as carcinoma, lymphosarcoma, inflammatory tissue and chronic granuloma, but subsequently pathologists of The Mayo Clinic and Columbia University rendered a verdict of lymphosarcoma. The patient had X-ray treatment (inadequate on account of his objection) and small doses of Coley's fluid, and was reported as well eighteen months later—the stomach appearing normal by X-ray except for reduction in size.

The results of treatment in the Brigham Hospital series are as follows: of the nine cases of lymphosarcoma of the stomach two died on the medical service shortly after admission, and autopsy showed in each inoperable primary lymphosarcoma of the stomach with metastases, and with terminal perforation. Two patients were explored, found inoperable (one had perforative peritonitis) and died a post-operative death. One patient explored and found inoperable, made an operative recovery and died three months later after having been admitted for X-ray treatment to another hospital, whose records, however, fail to show whether she was treated or not. One patient, No. S-31823, a man of seventy-one, had an exploratory laparotomy which revealed a large tumor mass occupying most of the stomach and adherent to and involving the left lobe of the liver; he made an operative recovery and had two X-ray treatments before discharge; the tumor diminished rapidly in size but the general condition did not improve and he died four months later. The biopsy of this tumor showed it to be composed of rather large round cells containing large nuclei, a rim of dark-staining cytoplasm and many mitoses, and it was designated lymphoblastoma. One patient, No. S-38857, was explored, found inoperable, given X-ray treatment and restored to apparently perfect health. Her story will be examined presently. Only two patients could be subjected to radical resection—one (No. S-14572) operated on by Dr. E. C. Cutler in 1921, had a resection of the pyloric third of the stomach with tributary involved nodes, made a normal convalescence but died of recurrence one and one-half years later, without having had supplementary X-ray treatment; the other (No. S-21507) operated on by the writer in 1924, had a segmental resection of the middle third of the stomach for an ulcerated lesion of the posterior wall, made a good recovery and was given two X-ray treatments on discharge from the hospital, but failed to report for later therapy. Six years later she wrote that she was "in better health than for years and had no stomach symptoms." Since then it has been impossible to trace her. The histological structure of the tumor showed "lymphoid tissue infiltrating the connective tissue and smooth muscle of the muscularis mucosa and submucosa; the cells are of lymphoid type with round nucleus of sharp outline and peripherally distributed chromatin, the amount of cytoplasm is small; there are occasional larger cells with basic staining cytoplasm; the growth is distinctly invasive and could not be confused with inflammation; there are many mitoses; the diagnosis is lymphosarcoma." (S. B. Wolbach.)

The treatment of the seven patients with lymphosarcoma of the intestines constituting the Brigham Hospital series resulted as follows: one died on the medical service shortly after admission, of metastases and perforation; three had exploratory laparotomy (two with palliative anastomoses) for inoperable tumors with extensive glandular metastases, followed by X-ray treatment; these patients died after intervals of four, seven and ten months respectively; three patients had resection (two by Dr. John Homans and one by the writer) without mortality; one of these could not be traced after his discharge; one

died of recurrence about one and one-half years later, and the third patient lived in perfect health for more than four years and died of angina pectoris—his physician reporting that he noted a palpable mass in the abdomen. Neither of these cases had X-ray therapy.

The history of one patient may be given in more detail, since it seems to point the way to a rational treatment of these cases.

L. M. G., No. S-38857—a woman sixty-three years of age, previously well, had complained for two years of unaccountable anorexia, indigestion and occasional nausea, and for ten months of increasing epigastric discomfort, loss of weight, pallor, asthenia and occasional vomiting without blood. Examination showed a mass in the epigastrium; the blood showed hæmoglobin of 65 per cent., red cells 4,600,000, white cells 5,850 and

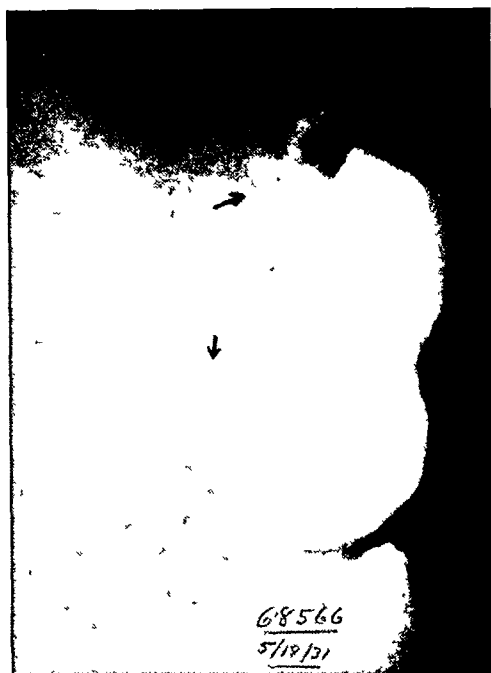


FIG 1

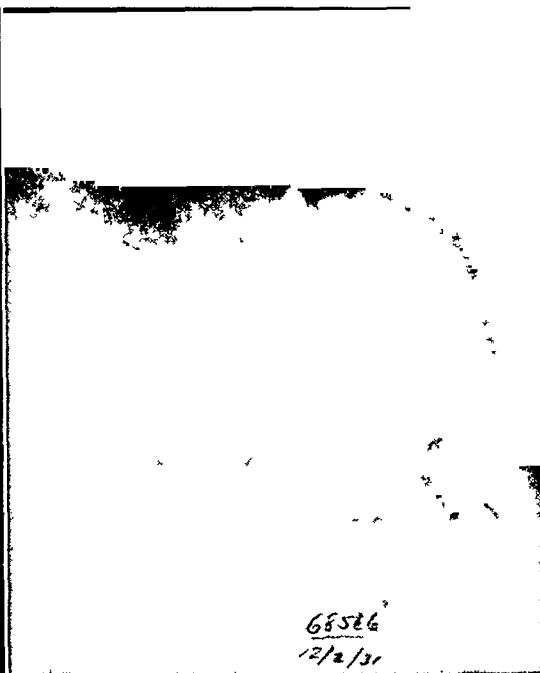


FIG 2

FIG. 1—Before radiation. Note the extensive filling defect of the antrum, the rigid appearing and irregular lesser curvature, and the defect caused by extrinsic pressure near the cardia.

FIG. 2—Seven and one-half months after radiation. Note the disappearance of the filling defect, the normal-appearing lesser curvature, and the absence of evidence of extrinsic pressure from masses of neoplastic glands.

normal cytology; X-ray (Fig. 1) showed an extensive filling defect of the pyloric antrum with rigidity of the whole lesser curvature, 25 per cent. six-hour residue, and evidence of extrinsic pressure near the cardia. No gastric analysis was made. The pre-operative diagnosis was carcinoma, probably inoperable. At operation by the writer on May 23, 1931, under avertin and supplementary ether anaesthesia, there was found an infiltrating tumor mass involving the whole antrum and the whole lesser curvature to the cardia; there was direct adhesion to and apparently involvement of the pancreas, and extensive glandular involvement along the lesser curvature with especially large masses about the cardia and celiac axis. The liver was uninvolved. Nothing unusual was noted about the tumor except that the diseased nodes were unusually large, rounded and elastic. Tissue was taken for immediate diagnosis and reported as probable small round-cell carcinoma. Convalescence was exceedingly stormy on account of inability to take nourishment and a moderate pneumonic or atelectatic complication. Paraffin sections of the tissue showed

PRIMARY LYMPHOSARCOMA OF STOMACH AND INTESTINES

"cells with scant basic cytoplasm whose boundaries are not distinct; there are many degenerating cells with small dense nuclei (pyknosis). There are many mitoses with peculiar dense, small, compact spindles of the nuclei; there are accompanying fibres simulating stroma formation but no arrangement into columns or glands and no secretory vacuoles are seen. The diagnosis is lymphosarcoma." (Figs. 3 and 4.)

X-ray treatment was begun on the fourteenth day. After a brief period of toxic manifestations necessitating mild and divided dosage, the response was most favorable, the nausea and vomiting ceased and nourishment began to be taken without discomfort. Six months later a barium X-ray (Fig. 2) showed complete disappearance of the filling defect of the stomach, including the evidence of extrinsic pressure from involved nodes near the cardia, the stasis had ceased, and no trace of a pathological process remained except a slight narrowing of the antrum as though by scar tissue. Fourteen months after the operation the patient writes that she has gained thirty pounds in weight, is



FIG. 3.

FIG. 3.—Tumor-cells invading fat tissue of the omentum, low power (magnification = 112).
Case No. S-38857.

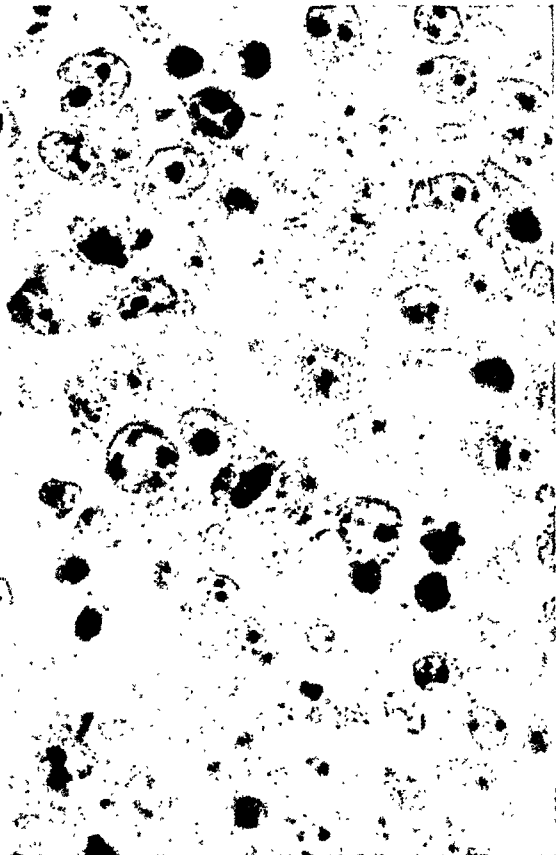


FIG. 4.

FIG. 4.—Tumor-cells; high power (magnification = 1500). Case No. S-38857.

regularly attending to her former clerical occupation, and is eating a liberal mixed diet without discomfort or symptoms of any sort.

Review of this material from the Brigham Hospital clinic confirms the general impression that lymphosarcoma of the gastro-intestinal tract is an uncommon condition and one carrying the gravest prognosis. It is as insidious as carcinoma, and seems to offer no greater probability of reaching the surgeon in an early and operable stage. In the stomach its radical operability is extremely low—in this series only 22.2 per cent., and its differential diagnosis from carcinoma, in the writer's opinion, absolutely defies the skill of the diagnostician, except in the rare instances where it occurs

in individuals so young that carcinoma would be a clinical curiosity. It is realized that these statements as to low rate of operability and gravity of prognosis are at considerable variance with views expressed by some authorities, but they are based on all the instances of the disease observed in a hospital of 240 beds during a period of nineteen and one-half years, on the medical and surgical services and in the autopsy room. In comparing the published evidence, the reader must again be warned as to the utter confusion which he will encounter, due to the failure of many writers to differentiate consistently or at all between the various types of "sarcoma" either in reporting their cases or in summarizing the literature, whereas, as has been noted, true lymphosarcoma differs widely in symptomatology, operability and prognosis from the fibro-, myo-, lipo-, myxo-, angio-sarcoma group—almost as widely, perhaps, as does true malignant osteogenic sarcoma of bone from giant-cell "sarcoma." When the intestine, especially the small bowel, is the seat of the disease, there appears to be probability of earlier diagnosis reflected in an operability in this series of 42.8 per cent., though the ultimate prognosis appears to be quite as grave as in the stomach.

Unless our conception of primary lymphosarcoma of stomach and intestine as originally a local disease is quite erroneous, radical cure by total extirpation is possible, and this should be the goal of general practitioner and surgeon alike, to be attained by early diagnosis and prompt operation. But it is amply evident that in therapeutic radiation we have a powerful substitute, if surgical removal is impossible, and in any case an important aid. Of the Brigham Hospital series, the gastric cases most benefited were No. S-21507, who had a resection followed by X-ray treatment and who reported herself six years later to be in perfect health, and No. S-38857 who had X-ray therapy for an inoperable lesion and who shows no clinical evidence of the disease after fourteen months, whereas No. S-14572—an apparently favorable case, had a resection without X-ray therapy and died of recurrence in eighteen months. An unfavorable result, but one in whom not much could be expected, was No. S-31823, an old man with extensive involvement of the liver, who lived but four months after exploration and X-ray treatment. The intestinal cases do not permit of dependable deductions; three very advanced inoperable cases who had X-ray were possibly benefited, and two patients with resection but without X-ray died with evidence of recurrence after one and one-half and four years. It may be believed that they would have survived longer if they had had the benefit of X-ray therapy.

In conclusion, the writer, on the strength of this survey of a group of patients with lymphosarcoma of the gastro-intestinal tract, wishes to urge the importance of exploratory operation and biopsy even in patients where the clinical evidence points strongly to inoperability, in order that the occasional case of lymphosarcoma may be identified and receive the benefit of X-ray therapy. It may be objected that this is unnecessary since radiation may be used in any event as a therapeutic test; the drawback to this plan is the usually uncomfortable and sometimes serious reaction of a debilitated patient

to X-ray therapy, but above all it seems important that adequate evidence should be accumulated as to the exact histological type of neoplasm which can be benefited by this means.

BIBLIOGRAPHY

- ¹ Ewing, James: Neoplastic Diseases. Second edition, Philadelphia, 1922.
- ² Mallory, F. B.: Principles of Pathologic Histology. Philadelphia, 1918.
- ³ Minot, G. R., and Isaacs, R.: Lymphoblastoma (Malignant Lymphoma). Jour. Am. Med. Assn., vol. lxxxvi, p. 1185.
- ⁴ Fedorow, D. N.: Primary Sarcoma of Stomach. Archiv. f. Klin. Chir., vol. clix, p. 119, 1930.
- ⁵ Balfour, D. C., and McCann, J. C.: Sarcoma of the Stomach. Surg., Gynec., and Obst., vol. 1, p. 948, 1930.
- ⁶ Douglas, J.: Sarcoma of the Stomach. ANNALS OF SURGERY, vol. lxxi, p. 628.
- ⁷ Haggard, W. D.: Primary Gastric Sarcoma, One of the Rarest of Diseases. Surg., Gynec., and Obst., vol. xxxi, p. 505, 1920.
- ⁸ D'Aunoy, R. D., and Zoeller, A.: Sarcoma of the Stomach. Am. Jour. Surg. (new series), vol. ix, p. 444, 1930.
- ⁹ Cutler, E. C., and Smith, J. A.: Lymphoblastoma of the Stomach. Surg., Clin. N. America, p. 1105, August, 1922.
- ¹⁰ Pemberton, J. deJ.: Sarcoma of the Stomach. Proc. Staff Mayo Clin., vol. iv, p. 17, 1929.
- ¹¹ Ruggles, H. E., and Stone, R. S.: Lymphoblastoma of the Stomach. Calif. and West. Med., vol. xxxiii, p. 486, 1930.
- ¹² Holmes, G. W., Dresser, R., and Camp, J. D.: Lymphoblastoma. Gastric Manifestations, Radiology, vol. vii, p. 44, 1926.
- ¹³ Ruppert, L. L.: Primary Endo-Gastric Lymphosarcoma. Wien Klin. Wchnschr., vol. xxv, p. 1970, 1912.
- ¹⁴ Rankin, F. W., and Chumley, C. L.: Lymphosarcoma of the Colon and Rectum. Minn. Med., vol. xii, p. 247, 1929.
- ¹⁵ Weeden, W. M.: Lymphosarcoma of the Gastro-Intestinal Tract. ANNALS OF SURGERY, vol. xc, p. 247, 1929.
- ¹⁶ Graves, S.: Primary Lymphoblastoma of the Intestine—Report of Three Cases. Jour. Med. Research, vol. xl, p. 415, 1919.
- ¹⁷ Loria, F. L.: Sarcoma of the Intestines. New Orleans Med. and Surg. Jour., vol. lxxviii, p. 201, 1925.
- ¹⁸ Cornier, E. M., and Fairbanks, H. A. F.: Sarcoma of the Alimentary Canal. Trans. Path. Soc. London, vol. lvi, p. 20, 1905.
- ¹⁹ Gunsett, and Oberling: Lymphoblastic Sarcoma of the Stomach. Assoc. Francaise pour L'Etude du Cancer, Bulletin, vol. xvii, p. 385, 1928.
- ²⁰ Strauss, A. A., et al.: Sarcoma of Stomach and Duodenum. Surg. Clin. N. America, p. 977, August, 1925.
- ²¹ Freeman, L.: Partial Gastrectomy for Peptic Ulcer and Lymphosarcoma of the Stomach with Recovery. Colorado Med., vol. ii, p. 362, 1928.

THE FATE OF THE OBSTRUCTED LOOP IN INTESTINAL OBSTRUCTION FOLLOWING AN ANASTOMOSIS AROUND THE OBSTRUCTION WITHOUT RESECTION

BY WILLIAM L. ESTES, JR., M.D., AND C. E. HOLM, M.D.

OF BETHLEHEM, PA.

WHEN intestinal obstruction is found to be due to a mass of small intestinal adhesions without gangrene or hernia, and the patient's condition justifies radical surgery, often the best procedure to relieve the obstruction is an entero-anastomosis around the adherent coils, a jejuno-ileostomy, ileo-ileostomy, or ileocolostomy with or without an enterostomy. In fact, entero-anastomosis has been urged as superior to enterostomy in the treatment of intestinal obstruction (Vaughan). In properly chosen cases an uneventful recovery usually follows this operation with complete relief of symptoms and subsequent good health, as the following cases demonstrate:

CASE I.—Male, aged forty-one years. Six months before he had had a cholecystectomy and appendectomy elsewhere. Normal recovery and good health except for constipation until five days before admission when symptoms of intestinal obstruction supervened, culminating in severe abdominal cramps with fecal vomit the day of admission. Immediate operation revealed a dense mass of small intestines adherent to the parietal peritoneum, to the base of the mesentery and to the cæcum in the right lower abdomen. One band of adhesions had formed a small orifice through which had prolapsed a coil of ileum which had become obstructed. This adhesion was freed and the obstruction released, but the remaining matted mass of intestine seemed so likely to obstruct again that an ileo-ileostomy around this area was rapidly done. The patient made an uneventful recovery save for the development of a small ischiorectal abscess. Examination three years later disclosed occasional slight constipation. No diarrhoea. Patient completely relieved, but still below weight.

CASE II.—Woman, aged forty-five years. Admitted April 5, 1930. She had in 1914 a bilateral oöphorosalphingectomy and appendectomy, tonsillectomy in 1920, hemorrhoidectomy in 1922. For six or seven years she has had intermittent acute cramps in lower left abdomen about every three or four weeks. Very brief duration. These were unrelieved by an operation in 1925 when omental adhesions were released. She had been markedly constipated and had noticed for three weeks a fullness in the lower left abdomen. Two days after admission to the hospital she developed a definite intestinal obstruction.

At operation, a mass of pelvic adhesions was found comprising most of the ileum, sigmoid, omentum, and transverse colon, evidently causing obstruction in the ileum. Adhesions of the transverse colon were freed and a lateral anastomosis was made from a point in the small intestine above the adhesions to the middle of the ascending colon—ileocolostomy. Recovery uneventful. Bowels moved spontaneously. Pain relieved.

Report two years later shows patient completely well. She has occasional constipation and no other intestinal symptoms since operation except belching of gas.

Summary.—Two cases in which entero-anastomosis was done for ileus due to massive intestinal adhesions had an uneventful convalescence and have remained well for two to three years after operation.

OBSTRUCTED LOOP IN INTESTINAL OBSTRUCTION

However, in the following cases a similar lateral anastomosis was done but a rather remarkable post-operative complication was encountered.

CASE III.—Male, aged twelve years. Admitted June 11, 1929. Three days before admission, the patient was seized with acute appendicitis, and at operation one hour after admission a gangrenous, perforated appendix was found within a large abscess walled off by intestinal coils. Appendectomy was done and the abscess drained. Convalescence was prolonged because of wound infection, but was otherwise uneventful. At a follow-up examination October 17, 1929, the patient was in excellent health. He remained free from abdominal symptoms until April 5, 1930, when intestinal obstruction occurred. At operation the terminal three feet of ileum was found adherent to itself, to the cæcum, and to the anterior abdominal wall. Adhesions were divided to release a three-inch loop of strangulated but viable ileum. Inasmuch as extensive, dense adhesions threatened future strangulation, a lateral anastomosis was established between the transverse colon and the ileum at a point proximal to the adhesions. Throughout the convalescent period, the patient had a good appetite and his general condition was excellent. A mild, painless diarrhœa, with considerable borborygmus and moderate distension of the lower abdomen developed one week before his discharge on April 22, continued in a mild form until May 4 when the diarrhœa became severe and painful, and vomiting occurred. These symptoms became progressively worse, and at readmission on May 9 the patient was undernourished, dehydrated, drowsy, and very toxic. The abdomen was moderately distended and generally tender, but there was neither rigidity nor palpable mass. At operation the following morning, the terminal three feet of ileum side-tracked on April 7 were found elongated to seven feet, greatly dilated, acutely inflamed and ulcerated, with the distal one foot completely obstructed in a mass of adhesions. The meso-ileum contained many lymph-nodes varying in size from a pea to a walnut. The colon was collapsed proximal and distal to the anastomosis. The side-tracked loop was resected from the anastomosis to the cæcum. During the manipulations of resection, several ulcerations of the loop perforated. The abdominal cavity was drained. A serious wound infection and the pre-operative debility prolonged the convalescence. A mild diarrhœa persisted throughout the patient's stay in the hospital and continued for several months after his discharge. Recuperation was slow for several months following his return home, but at the last follow-up examination one year later, May, 1931, he had gained twenty-five pounds in weight and his general health was excellent.

Summary.—A boy, aged twelve, nine months after an appendectomy and drainage of an appendiceal abscess, developed an intestinal obstruction due to massive post-operative adhesions of the ileum which was relieved by an ileocolostomy around the obstructing coils. Post-operative diarrhœa supervened with low abdominal pain and distention and borborygmus which failed to respond to treatment. One month later re-operation was necessary. The terminal side-tracked ileum was found to be a hugely distended mass of adherent intestinal coils, ulcerated, acutely inflamed, and obstructed. Following resection of this ulcerated and obstructed mass, the patient made a slow but satisfactory recovery and has remained well ever since.

CASE IV.—Male, aged sixteen years. Admitted November 18, 1929, with symptoms and signs of acute intestinal obstruction of two days' duration. At operation several loops of terminal ileum were found matted together and adherent to the lateral wall of the pelvis, around a gangrenous Meckel's diverticulum, causing a complete intestinal obstruction. The involved loops of ileum with the Meckel's diverticulum were resected, following which a lateral anastomosis was performed between the ascending colon and the ileum, four inches proximal to the resection. The four-inch blind limb of ileum distal to the anastomosis was placed over the large defect in the posterior parietal peritoneum of the pelvis where the intestinal coils had been adherent. Ten days after the operation the patient became slightly distended, and began having mild attacks of visible

peristalsis in the lower abdomen which recurred during the remainder of his stay in the hospital. His general condition was good. After going home December 7, 1928, the attacks of visible peristalsis recurred with increasing frequency and were associated with marked borborygmus and pain. He had from two to six loose bowel movements daily, the pain being relieved shortly before defecation. His symptoms becoming progressively worse, he was readmitted January 26, 1929, and was operated upon two days later. The four inches of blind ileum distal to the anastomosis performed the previous November had become greatly elongated and distended, and filled the lower half of the abdominal cavity. It was coiled upon itself, with dense adhesions to the cæcum and pelvic wall. The blind end of the ileum was partially freed from adhesions when the patient's general condition became too serious to permit resection, and the operation was hastily terminated by performing a lateral ileo-ileostomy between a point near the end of the blind limb and an area immediately proximal to the former ileocolostomy. Recovery was prompt, and the patient was discharged February 9, 1929. *Examination* September 21, 1929, showed that the patient was much underweight, due to a severe diarrhœa of four months' duration. There had been occasional attacks of distension, borborygmus, and painful peristalsis. He was placed on a strict diet and January 2, 1930, was greatly improved, although abdominal distension and a mild diarrhœa had persisted. His appetite had been good throughout.

The patient was readmitted January 7, 1930, during an aggravation of the abdominal symptoms, and he was operated on three days later. The lower two-thirds of the abdominal cavity were filled with the hugely elongated and dilated blind loop of terminal ileum which was fully eighteen inches in length and three to four inches in diameter and showed marked ulceration throughout. The mesenteric lymph-glands were all markedly enlarged. Proximal to the ileocolostomy the ileum seemed normal. The blind loop of ileum was freed of adhesions and completely resected and the sigmoid sutured over the denuded areas. The patient was discharged January 28, greatly improved, although he still had a mild diarrhœa. The diarrhœa persisted for several weeks after his return home. Fifteen months later, he was in excellent health, had gained thirty-five pounds in weight and had no gastro-intestinal complaint.

Summary.—A boy of sixteen years, after resection of the terminal ileum, for intestinal obstruction due to a Meckel's diverticulum, and lateral ileocolostomy with a short loop of blind ileum left distal to the anastomosis, developed a severe enterocolitis with low abdominal distension, pain, and borborygmus and was only slightly relieved until a complete resection of the blind loop was finally performed, said loop having become hugely elongated, distended, and ulcerated, filling almost one-third of the abdomen. He has remained well.

Comment.—This fourth case has been cited because of its great similarity to the third, due to the ulceration and dilatation of the short blind end of ileum beyond the anastomosis which had been allowed to remain. In defense of leaving this small portion of blind ileum it should be stated that neither the omentum nor the sigmoid was available to cover the denuded pelvic wall. It was therefore feared that post-operative small intestinal adhesions might again produce obstruction. Hence, it was deliberately planned to use this blind end to cover over the raw area and to meet later any complications that might result from this procedure, in spite of the knowledge that elongated blind ends in lateral anastomosis are universally condemned.

Both these cases showed what seemed to be a similar clinical entity—a post-operative enterocolitis evidenced by diarrhœa, visible peristalsis, abdominal distension and colicky pain and borborygmus caused by stagnation, dila-

OBSTRUCTED LOOP IN INTESTINAL OBSTRUCTION

tation, and ulceration of an obstructed or blind loop of intestine, that required resection of the involved loop for cure, in spite of a fecal path around the obstruction.

A survey of recent literature fails to reveal any reference to ulcerative enteritis as a complication of entero-anastomosis for intestinal obstruction. Vaughan,* however, in arguing for entero-anastomosis as against enterostomy in ileus, has cited one case in which "symptoms were much improved by entero-anastomosis," but resection of the side-tracked intestine was necessary for complete relief; in another case, after the entero-anastomosis, recurring attacks of abdominal pain and vomiting persisted and resection of the adherent masses of small intestine was necessary in which "many obstructive points were encountered forming dilated bowel areas filled with fecal matter and pus." Three other of his cases remained well without requiring resection.

In view of the fact, therefore, that after entero-anastomosis certain cases recovered without post-operative untoward incident, and others required resection of the obstructed loops because of an ulcerative enteritis, it seemed worth while that one of us (C. E. H.), should attempt experimentally to produce a post-operative enteritis after a lateral anastomosis to ascertain why this complication arises.†

These experiments were carried out in the experimental surgical laboratory of the University of Pennsylvania through the courtesy of Dr. I. Ravdin, whose kindness is hereby gratefully acknowledged.

It was surmised that the reason for this post-operative complication is that obstruction occurred or persisted in the side-tracked loop which caused stagnation, difficulty in emptying against the normal fecal current, and gradual dilatation and ulceration. When this loop remains unobstructed, convalescence is normal and the patient remains well.

It seemed essential to determine: (1) Is obstruction in the side-tracked loop after a lateral anastomosis the cause of the dilatation and ulcerative enteritis? (2) Does ulcerative enteritis result (a) After ileo-ileostomy? (b) After ileocolostomy? (c) When a simple blind loop of ileum is left distal to the anastomosis?

Accordingly, an obstruction was created in the ileum five to six inches proximal to the ileocecal valve in five dogs, by severing the bowel transversely and inverting both ends. The closed ends were approximated by suture in order to maintain the general relations of the ileum. In three a lateral anastomosis was made between the ileum twelve to fifteen inches proximal to the obstruction and the colon five to eight inches distal to the ileocecal valve (ileocolostomy). In two an ileo-ileostomy was established around the obstruction from points six inches and fifteen inches respectively proximal

* Vaughan: Transactions of the American Surgical Association, vol. xlviii, p. 266.

† Detailed experimental work to be reported elsewhere. Subject matter for a thesis as part of the requirement of the Graduate School of Medicine of the University of Pennsylvania for the degree of Master of Medical Science in Surgery.

to the obstruction. In two other dogs the ileum was severed, its ends turned in and an ileo-ileostomy made, permitting a blind loop of ileum to extend respectively six inches and eight inches beyond the anastomosis.

The post-operative course in the seven dogs was practically identical. They were fed a liquid diet for four days, a soft diet for three to four weeks and thereafter a general diet, including bones. For two to five weeks they remained well and active. A mild diarrhœa then developed and the dogs began to lose weight, became listless, and the diarrhœa progressively worse. Borborygmus and distension were noted. Two died of a perforated ulcer in the obstructed loop six weeks after operation, and the remainder were sacrificed.

Nine to fourteen weeks' post-operative autopsies showed practically identical findings in all these dogs whether ileo-ileostomy or ileocolostomy had been done or a blind loop of ileum left. The anastomoses were well healed and free from infection. The side-tracked and obstructed loop of ileum had elongated 50 per cent. and was dilated three to four times its normal diameter and its lymph-glands were enlarged. Numerous ulcers of various sizes were scattered throughout the loop and occasionally in the ileum proximal and the colon distal to the anastomosis. The dogs that died spontaneously died from a perforation of one of these ulcers. Furthermore, an advanced and widespread parenchymatous degeneration in liver and kidney occurred in all animals and it may be assumed that this occurs in clinical cases and would explain the great debility and slow convalescence frequently encountered.

Experimentally, then, an *ulcerative enterocolitis affecting chiefly the obstructed loop was produced in every way similar to the ulcerative enteritis of the clinical cases* by an obstruction in the ileum and a side-tracking anastomosis around the obstruction whether said anastomosis was ileo-ileostomy or an ileocolostomy. A similar condition was produced if a blind loop was left beyond or distal to the anastomosis.

It would seem, therefore, that with an entero-anastomosis for the relief of intestinal obstruction due to a mass of small intestinal adhesions if the obstruction recurs or persists an ulcerative enteritis and dilatation of the obstructed loop will occur, as the obstructed loop acts like a blind end left beyond a lateral anastomosis. If the obstruction is relieved and does not recur, the patient remains well.

Conclusion.—(1) Following an entero-anastomosis around a mass of intestinal adhesions, uneventful recovery is to be anticipated unless intestinal obstruction in the adherent coils persists or recurs.

(2) If the obstruction persists or recurs there will follow an ulcerative enteritis and dilatation of the obstructed loops leading perhaps to a general enterocolitis evidenced by diarrhœa, visible peristalsis, and borborygmus. Resection of the side-tracked ulcerated intestine will be necessary.

(3) Entero-anastomosis for intestinal obstruction must be looked upon as a possible first-stage operation of which resection of the obstructed loops may be required as a second stage.

OBSTRUCTED LOOP IN INTESTINAL OBSTRUCTION

(4) No matter whether the anastomosis be an ileo-ileostomy or an ileo-colostomy, in the presence of obstruction the ulceration will occur.

(5) That the obstruction and subsequent stagnation play the major part in the cause of the ulceration seems proven by the fact that clinically and experimentally in a blind loop of intestine left distal to an anastomosis a similar ulceration will be produced; in other words, if the obstruction in the side-tracked intestine remains it acts like a blind loop left distal to a lateral anastomosis.

(6) In the presence of *acute* obstruction it would be unwise to consider primary resection of the obstructing coils unless gangrenous, but if at the time of lateral anastomosis it is *certain* that the obstruction in the adherent area remains, the two-stage operation must be definitely planned.

MAGGOTS AND OSTEOMYELITIS

BY WALTON MARTIN, M.D., AND WILLIAM G. HEEKS, M.D.
OF NEW YORK, N.Y.

AMONG the distinguished contributors to the fifth volume of the proceedings of the Inter-State Post-Graduate Medical Association appears the name of the late Dr. William Stevenson Baer, Clinical Professor of Orthopædic Surgery, Johns Hopkins University. In the report of his clinical address, are two pages on "Viable Antiseptics in Chronic Osteomyelitis."¹ The meeting was held in Detroit in October, 1929. In the meeting, as Doctor Baer was about to throw films on the screen to illustrate his treatment of osteomyelitis by maggots, he said: "I hope the editor of the American Medical Journal is here. I see in the August number there is a little squib put down on this subject under 'Fakes and Nostrums.'" I have been unable to find this reference, but if Doctor Baer were alive today, he could make no such comment. In the Journal of the American Medical Association of January 30, 1932, appeared among "New and Non-official Remedies," accepted by the Council on Pharmacy and Chemistry, "Surgical Maggots, Lederle."² In the March 12 issue, there is a two-page advertisement by the Lederle Laboratories on "The Development of Surgical Maggots," in which appears the statement that "The acceptance of Surgical Maggots, Lederle, by the Council on Pharmacy and Chemistry attests the approval of the maggot treatment by leading orthopædic surgeons. Its effectiveness has been so outstanding in chronic osteomyelitis that the treatment has been applied to other types of suppurating and sloughing wounds. Several clinics are using maggots in their out-patient departments on ambulatory cases of chronic leg ulcers and even carbuncles. Tuberculous abscesses and tuberculous bone lesions appear to respond with gratifying results." In the April 2 issue of the Journal of the American Medical Association there are two pages on the subject. Even at the meeting in Detroit, Doctor Baer's work received the endorsement of Dean Lewis, Professor of Surgery at Johns Hopkins University, who spoke at the end of a paper on acute osteomyelitis of Doctor Baer's results in chronic osteomyelitis as astonishing. He writes that "The grubs introduced by him in these bone cavities have separated the living from the dead bone without injuring the living bone."³

The interest in the method has not been confined to the medical profession. It has been considered to be of sufficient interest to appear in journals written to spread abroad scientific knowledge. In the *Science News Letter* (a weekly summary of current science), of August 22, 1931, there is an article by Jane Stafford on "How Clean Larvæ of the Blow Fly Are Carefully Bred to Destroy Germs Rather than Spread Them." I cannot do better in showing how so-called advances in science are reported than to quote extensively from this article. "The feeling about maggot treatment is not much different from the feeling your eighteenth-century ancestors had about small-pox vaccination . . . all

MAGGOTS AND OSTEOMYELITIS

sorts of arguments had to be refuted. Some people did not think it would give protection. Others thought it was too dangerous. . . . The use of maggots, tiny crawling larvæ of the blow flies, to fight infection in wounds and to clear up the bone disease, osteomyelitis, was developed from observations made during the World War by an American surgeon, Dr. William S. Baer, of Baltimore. . . . The maggot treatment will probably not meet with as much opposition among physicians as did Jenner's vaccination method, because of Doctor Baer's high standing in the medical profession and the esteem with which physicians both in Baltimore and elsewhere regarded him."⁴

The following is taken from a recent newspaper regarding the maggot treatment as presented at the meeting of the American Medical Association in New Orleans: "Tiny pinhead maggots are proving expert surgeons in the treatment of bone infections, according to scientific exhibits of the American Medical Association meeting here today. The maggot surgeons were called into cases of bone infection where it was found impossible to remove all the infected bone with a knife. The maggots were sterilized before being put to work."⁵

As these statements, either based on or suggested by the observations recorded by Doctor Baer, are at variance with common knowledge, readily accessible in standard text-books on entomology, pathology and surgery, it has seemed to me worth while reviewing the subject carefully. I shall first refer to the statements regarding the anatomy and physiology of the maggot, then to those regarding the course of osteomyelitis and finally to those referring to the healing of an open contaminated wound.

In the Detroit meeting and as I heard Doctor Baer talk, in presenting his patients in his clinic in Baltimore in 1929, the efficacy of the treatment is based on the notion that the maggot gnaws away dead bone from living bone and shows a special activity in destroying bacteria. "The maggot goes directly to the bone itself. He likes bones as dogs do, rather than meat. He goes and gets at the bone and separates any sequestrum from the living bone, and not until he gets down to the bone itself, where it bleeds, will he stop gnawing the dead bone."

In the paper arranged for publication after Doctor Baer's death by Dr. George E. Bennett on "The Treatment of Chronic Osteomyelitis with Maggots,"⁶ these statements are modified; the maggots are said to suck up bacteria and consume dead tissue, bacteria pass through the intestinal tract and some bacteria are killed. The maggot is said to "work around and separate small sequestra and dead particles of bone still attached to normal bone and *seem* to gnaw down to the bone until bleeding bone is reached." But farther on, in the same paper, it is written that "the maggot has an intuition as to where the line of demarkation is going to appear and eats down to that line and thus removes all potential sequestra."

The bacteria are said to begin to diminish with the first hours of application and the original paper is headed "Viable Antiseptics."

These statements are not in agreement with those recorded by competent scientific observers and set down in standard text-books of entomology. There has been no disagreement about the fact that the maggots are capable of taking only liquid nourishment, since the original observation of Fabre made over forty years ago. Their mouth parts are so arranged that anything

like gnawing is impossible. There has been no disagreement regarding the hooklets near the cephalic end being organs of locomotion. There has been no disagreement about the maggots of blow flies living in nature with myriads of the bacteria of decomposition furthering, rather than inhibiting, their action. Common observation has made this familiar to all who have watched the decomposition of the cadaver of any small animal. The stench of putrefaction and the buzzing of blue-bottle flies are too frequently associated to escape notice. For many years, the maggots were supposed to be generated by corruption. "Maggotes ben wormes that brede of corrupt and rotyd moysture in flesshe" (1398). It is a common observation to see bones, hair and hide left after the flesh has melted away under the combined action of bacteria and larvæ. When there is no odor of putrefaction, the flies no longer visit the carrion.

But there has been much discussion as to the external digestion of the maggot and to the share played by bacteria in preparing suitable liquid food. It can no longer be doubted that ferments, to some extent, pass out of the body of the maggot into the medium in which it is living, and recent work has confirmed the observations and experiments of Woolman, that eggs can be hatched and maggots reared without bacteria, although growth under these conditions does not seem to be entirely normal.

It is of interest to review the work that led to these conclusions.

FABRE⁷ forty years or more ago, in one of his delightful studies on the habits and behavior of insects, brought out that the mouth parts of the maggots of the flesh flies are only adapted to sucking up nourishment in liquid form; that the two hook-like processes near the head are organs of locomotion. He placed larvæ in test tubes with fragments of protein material and showed how the material first became fluid, then was absorbed. He concluded that some subtle pepsin-like ferment was secreted externally which acted on the protein material and reduced it to a broth readily sucked up by the maggot. In another article, he demonstrated, by careful observation, a fact known for years, that cadavers in which the flesh flies lay their eggs and larvæ develop, liquefy much faster than those abandoned to the action of the bacteria of putrefaction alone.

In 1907, GUYÉNOT⁸ published a paper on the digestive apparatus and the digestion of the larvæ of the flesh flies, in which he attempted to disprove the conclusions of Fabre regarding the external digestion by a pepsin-like ferment. Guyénot's conclusions are accepted and set forth by L. O. Howard,⁹ principal entomologist of the United States Department of Agriculture, in a book on the fly (copyrighted 1911) and by A. D. Imms, professor of entomology in British India, in the "General Text-book of Entomology." IMMS (second edition, 1930)¹⁰ gives the following summary of the views of these two observers: "External digestion has been observed in divers orders of insects; in some cases it is of a preliminary nature only, while in others, the essential processes of digestion appear to take place outside the body. Fabre states that the larvæ of *Lucilis Cæsar* (one of the flesh flies) discharges the digestive secretion over the carrion that serves as its food. By means of a ferment analogous to pepsin, the protein matter is liquefied and subsequently imbibed. This explanation is disputed by Guyénot (1907) who states that the digestive secretion exhibits no such properties and that the functions ascribed to it by Fabre are in reality performed by symbiotic micrococci which are abundant in the food reservoir of the maggot."

It may be of interest to give in detail Guyénot's conclusions. He writes: "The diges-

tion of the larvæ of flies results from a special mechanism, if it be true that the chemical elaboration of the food takes place outside, instead of inside, the digestive tube."

The hypothesis of this external digestion rested on the observation that the larvæ require nourishment in liquid form, and this conclusion is drawn from the following:

(1) He never saw larvæ in the presence of solid or pap-like food absorb the least particle of it before it had been made liquid.

(2) Repeated examination of the digestive tract of the larvæ (crop and intestines) showed that the contents were always liquid, and contained minute solid bodies visible only under the microscope.

(3) The larvæ have no apparatus of mastication, the cephalic hooklets serving only for the purpose of fixation and locomotion, being so arranged that anything like mastication is impossible. Not a particle is absorbed if maggots are placed in contact with finely divided carbon: if water is added to make a paste, only microscopical particles are taken in with the fluid.

Guyénot gives drawings of the mouth, the pharynx, the cephalo-pharyngeal skeleton with the hooklets, the crop and the intestinal tract of the maggot.

WOOLMAN¹¹ in 1922, in the *Annals of the Institut Pasteur*, in an article on the nutrition of the larvæ of flies, again reviewed the subject. After referring to observations of Guyénot, who had drawn the conclusion, as we have already pointed out, that the maggot secretes no soluble ferment, but lives on albuminous material liquefied by bacteria of decomposition, Woolman writes that "Nothing is easier than to confirm the digestive action, to some extent, of divers ferments outside the larvae, of which Fabre speaks. It suffices to take aseptic larvæ and place them on gelatine to see it rapidly liquefy. A glycerine extract of the pap upon which the maggots have fed shows the presence of protease." "It goes without saying," he writes, "that in nature, the action of proteolytic bacteria is added to the action of the digestive ferments of the maggot, but when the larvæ are placed in suitable conditions, development is perfect without bacteria."

In April, 1931, R. P. HOPSON, in the *Journal of Experimental Biology*,¹² in an article on the nutrition of the blow-fly larvæ, made a most painstaking study of the gastro-intestinal tract of the maggot and the ferments secreted. The crop appears to function as a storage organ only. The paper gives an account of the histology of the mid-gut and the physiology of digestion. The mid-gut of the larvæ of the variety of flesh flies investigated can be divided into three distinct regions, termed anterior, middle and posterior. Trypsin, peptidase and lipase are present in the mid-gut, the enzymes being concentrated in the anterior and posterior segments. The proteolytic enzymes persist in the excreta, therefore external digestion to some extent can occur without the aid of microorganisms.

No evidence has been presented by a competent observer that any ferment with solvent action on bone exists.

To estimate the results of treatment, it is well to study the individual case reports and to review the natural course of the disease:

"In some cases which had chronic osteomyelitis," Doctor Baer reported, "from two to ten years, and had been operated on two to fifteen times . . . we cut down on that wound (I assume by 'that wound' Doctor Baer referred to the sinus tract leading down to necrotic bone) and took out whatever sequestra we could find in the wound itself; then, after twenty-four hours, introduced as many maggots as the wound would hold, every fourth day introducing new maggots and washing out the old ones until at the end of that time all those wounds were healed. We had some twenty-one cases, both of compound fracture and ordinary chronic osteomyelitis of most of the bones of the human body and we have yet to have any one of those twenty-one cases fail to heal." (1929.)

In Doctor Baer's second paper details of treatment and results are given. As compound fractures and tuberculosis of bone joints present a problem somewhat different, I shall first refer to the case of hematogenous staphylococcus osteomyelitis, and as in young

children the cure is effected more readily than in older children and adults where the infection has persisted for a considerable period of time, I have selected all the case reports of staphylococcus osteomyelitis in patients of fourteen years or older.

In the table of case reports, there are twenty-eight such cases of staphylococcus osteomyelitis. We find only six reported as healed: case Nos. 8, 30, 38, 57, 73 and 82 (21.4 per cent.). Three are reported as "practically healed," Nos. 42, 62 and 63. In Case 42, the operation was performed December 3, 1930, the maggots inserted twenty times. On May 18, five months later, it was reported as "practically healed." I assume that this term is applied when a small dry crust or superficial sinus with a very small amount of discharge is left, which in the opinion of the surgeon is about to heal. Case 62, two months after the operation, was reported "practically healed." Case 63 was operated on June 13, 1930; the maggots were inserted twelve times; two and a half months later it was reported "practically healed," although in the report published six months later, no follow-up is reported.

Case Nos. 80 and 87 are reported as almost healed; in No. 80, the maggots were inserted five times. The operation was performed September 11, 1929, and on November 23, 1929, it was reported as almost healed. In case No. 87 the operation was performed June 26, 1930; the maggots were inserted seven times and six months later reported as almost healed.

Case Nos. 15, 59, 61, 65, 68, 70, 72, 74, 76, 84, 85, 88 and 89 are reported as improved; No. 15 is reported as much improved.

Case Nos. 66, 67 and 69 are reported as unimproved. In No. 66 the operation was performed July 10, 1930; the maggots were introduced eighteen times. The patient was sixty-eight years old, had had the lesion for ten years and had had four previous operations. Case No. 57, osteomyelitis of the right second finger, thirty-three years old, was operated on March 28, 1930; three times the maggots were introduced. On April 10, 1930, he was reported as unimproved. Case No. 69: There was osteomyelitis of the right femur and right ulna. Operations were performed on May 13, August 21 and October 28, 1930. The maggots were introduced twenty-eight times.

It is notoriously difficult to study the efficacy of treatment by controls such as used in all experimental work. True controls of clinical material in infection are nearly impossible on account of the variation in dosage and the virulence of the microorganism and the susceptibility of the host. But curiously enough, rough controls, so to speak, are furnished by studying the reports of Kalowski¹³ on the "Orr Treatment of Osteomyelitis" in the same volume of Bone and Joint Surgery as Doctor Baer's last report appears.

After an operation in which, through adequate incision of the soft parts, all sequestra were removed, overhanging bone edges made shelving, and the whole wound, packed loosely, wide open, with vaseline gauze, the joints above and below the diseased bone were immobilized. The forming granulations were left undisturbed by allowing the gauze packing to remain in place. One hundred thirty cases are recorded, ninety-nine are recorded healed, twenty-two unhealed, six amputations and three deaths. The number of healed is 76.15 per cent.

Unfortunately, details of the individual cases are not given; compound fractures and tuberculous osteomyelitis are included; no distinction is made regarding phases of infection; percentages are drawn from widely dissimilar types of infection. However, grouping all the cases together in similar fashion from Doctor Baer's records shows thirty-eight healed in eighty-nine cases (43.8 per cent.), or, including as healed the four reported as "practically healed," 47 per cent.

Further, to form a just appraisal of any method of treatment, it is necessary to review and consider the natural course of osteomyelitis.

It may be well to review first the experimental work which has contributed to an exact understanding of the course of hematogenous infection in bone. Over forty years ago, the course of infection was clearly demonstrated by a number of carefully carried out experiments. Lannelongue and Archard,¹⁴ in France (1890), Colzi¹⁵ in Italy in 1889 and later, Lexer¹⁶ in Germany (1897)—all produced by numerous experiments not only the general features but many of the details of the disease as it is presented in man.

Further, a second group of experimenters in attempting to elucidate the fate of microorganisms injected into the blood current, although not directly concerned with the lesions of osteomyelitis, recorded a number of careful observations on the distribution of microorganisms and minute inert foreign particles of the size of staphylococci in the bone-marrow, as well as the spleen, liver and other tissues of the body (Wyssokowitsch,¹⁷ Hoba,¹⁸ *etc.*).

These experiments and observations make it clear that staphylococci and minute particles of inert lamp black introduced into the ear veins of rabbits, for example, rapidly disappear from the circulating blood. If the animals are killed, the particles are found scattered throughout the body, but especially in the liver, spleen and bone-marrow, settling out where the circulation in the wide capillary area is unusually slow. There they come in contact with special cells which have the property of taking up minute foreign particles and destroying living microorganisms. If the mass action of introduced organisms is sufficient, or the local resistance is lowered by a variety of external conditions, instead of being destroyed, they start to grow, pouring countless millions into the blood-stream.

The conditions in the growing bone of young animals is peculiar. The capillary mesh work is so formed that particles of carbon introduced settle out in such masses in the capillaries of the marrow in the portion of the shaft of the long bones near the epiphyseal cartilages, that the structure can no longer be made out.

In all generalized infection, the capillary mesh work of the bone-marrow is concerned in the destruction of countless microorganisms. If there is local lowering of resistance, the lodged microbes may make their presence known by local lesions in one of the bones and the contiguous joints, thus streptococcus osteomyelitis, pneumococcus osteomyelitis, typhoid osteomyelitis, tuberculous osteomyelitis, syphilitic osteomyelitis, even glanders osteomyelitis, *etc.*, are recognized, as well as similar forms of arthritis. Each has certain characteristic features and predilection in localization.

But all forms imply that the infecting agent has been deposited in the capillaries of the bone-marrow during the generalization of infection; each shows a great variety in the lesions produced. The reaction may be so slight that it escapes clinical observation, or the reaction may lead to extensive local lesions accompanied by exudate and mass necrosis.

The acute hematogenous osteomyelitis of childhood, as it is understood clinically, is due usually to staphylococcus (75 per cent.); occasionally to streptococcus.

LANNELONGUE¹⁰ was able to make the following distinctions between these two forms experimentally. The animals used were young rabbits, weighing between 500 to 1,300 grams. The inoculations were made in the veins of the ear. The quantity injected varied between 0.25 and one cubic centimetre of bouillon culture. The amount necessary to create the lesion was a little larger for the streptococci than for the staphylococci. The histological examination of the bone showed lesions in every way similar; there were masses of microorganisms in the medullary substance and in the Haversian canals. There were also accumulations of microbes in the capillaries in the neighborhood of the epiphyseal cartilages. The morbid localization in the skeleton showed itself under three forms; sub-periosteal abscesses, abscess and purulent inter-medullary infiltration and articular suppuration. The intra-osseous foci was situated five times in the inferior portion of the femur, three times in the inferior portion of the tibia, once in the inferior extremity of the humerus and once in the superior portion of the ulna. Suppurative arthritis was observed in both forms, but far more frequently in the streptococcus inoculation. A detail of interest was that in the suppurative arthritis in both forms, the articular cartilage presented no appreciable alteration, even after it had been exposed to the purulent exudate, except that there were particles of fibrin adherent to the joint surface and infiltrated with microbes; the articular cartilage was intact, its fundamental substance was not altered, in contrast to the diaphyseal cartilage which was frequently invaded and destroyed. The bone lesions were accompanied by necrosis far more frequently in staphylococcus infection.

Acute osteomyelitis of infants and young children represents the osteo-arthritic localization of a generalized pyogenic infection.

It has been my good fortune to have associated with me on my service at St. Luke's Hospital, for the past twenty years, the attending surgeon to the Babies Hospital. Knowing my interest in generalized infection and its relation to osteomyelitis, Dr. W. A. Downes, the late Doctor Bolling and at present Doctor Donovan have been kind enough to allow me to see in consultation from time to time infants and young children with general staphylococcus and streptococcus infection, especially those with osteo-arthritic localization, and have given me the opportunity to study and follow residual bone lesions. I have appended to this paper a group of case reports prepared by Doctor Heeks, assistant surgeon to my division at St. Luke's Hospital, and assistant surgeon to the Babies Hospital. The study of the sequence in the pathological lesions in the patients that have recovered is most interesting and the autopsy findings are of equal interest. They are startlingly similar to the findings in experimental inoculations reported by Lannelongue. These infants and young children are of especial interest in so far as they probably represent infection in non-sensitized or imperfectly sensitized subjects. I believe the acute osteomyelitis of adolescence and the uncommon acute osteomyelitis of adults is best explained as an autogenous or exogenous reinfection in sensitized subjects, with high general resistance and marked tendency to local destructive lesions; the autogenous infection resulting from the awakening of hibernating microorganisms from an undetected latent foci in the medullary cavity; the exogenous infection from the settling out in the bone-marrow of microorganisms from primary lesions in skin or mucous membrane similar to the primary lesions which precede acute staphylococcus infec-

tion in infancy and early childhood, such as furuncles, pustules, infected cracks and fissures, small infected wounds, etc.

It is well recognized that a staphylococcic lesion of the dense derma, such as is seen in a furuncle and representing focal infection in a sensitized subject, usually terminates, if left to itself in a local area of necrosis, and that the necrotic area is surrounded by an area of infiltrated, swollen, reacting tissue; and that when the necrotic core comes away as a purulent blob, the whole process rapidly subsides; further, that a focal staphylococcal infection which has led to a purulent exudate, surrounded by a wall of reacting tissue, rapidly subsides when free exit is given to the purulent exudate.

Similar lesions occur when staphylococci are implanted in bone, but they are modified by the impregnation of the ground substance of the connective tissue with the salts of lime, making a framework which dissolves and disintegrates with difficulty, and by the process taking place in such a way that the reacting new-formed bone tissue usually locks in, to a greater or less extent, the necrotic tissue.

Chronic staphylococcus osteomyelitis is in most instances but the expression of these simple considerations. Chronic osteomyelitis may be said to represent a residual or tertiary lesion in generalized staphylococcic infection, modified by the peculiarly resistant bone tissue, with its two characteristic groups of cells—one group concerned with the laying down of new bone in the reacting area, the other group concerned with the eating away of bone resulting in the separation and absorption of dead bone. It represents a terminal stage of infection with a marked natural tendency toward recovery.

The failure to cause sound healing in chronic pyogenic osteomyelitis is due to the imprisonment of necrotic bone or small foci of infection, by the surrounded new-formed bone, and by the rigid walls of bone cavities formed about such foci as infection. The sequestrum, that is to say, the detached necrotic bone has the same significance in the tissues as any infected foreign body has. From time to time the tissue may heal about it, if the foreign body is very small and the infection much attenuated, but sooner or later, due to local lowering of resistance, the latent infection becomes active, exudate collects under pressure and escapes externally. With each reinfection the surrounding tissue becomes thicker and the thickness and rigidity of the walls bears not only relation to the duration of the infection but to the amount of tension or pressure set up by the exudate, when it is intermittently damned back or imperfectly drained.

This is true for chronic infection in bone as it is true for the thickened pleura in chronic empyæma.

If left untreated, if the exudate is allowed time after time to collect under pressure, with intermittent discharge, if it is repeatedly reinfected with new microorganisms from without, the reacting new formed bone gradually becomes thicker and denser. Enormous thickening may occur in the new bone about the sequestrum, which is but a porous insoluble foreign body, saturated by decomposing wound discharges and swarming with bacteria.

If the sequestrum is minute and the infection attenuated, intermittent low-grade infection may result, making the various forms of condensing and hypertrophic osteitis.

Chronic abscesses, shut in by eburnated bone, rigid walled bone cavities, hyperosteoses, local or extending over the entire shaft, various forms of condensing osteitis, imprisoned and free sequestra and attached necrotic bone and bone fistulæ connected with any of these forms, through which, for months and years, continuous or intermittent purulent discharge takes place, and low-grade secondary infection in the reacting bone formed by dammed back exudate make up the clinical picture of chronic osteomyelitis. A most satisfactory description of the various forms of chronic osteomyelitis was given by Lannelongue fifty-three years ago. It is based on eighty observations.

Any operation that sets right the morbid anatomical condition in this terminal stage results in permanent cure, but the difficulty of the operation bears a direct relation to the duration of the disorder and the preceding management of the case and the anatomical situation of diseased bone.

In the terminal stage, the essentials of treatment are the removal of sequestra and the obliteration of rigid walled cavities. The treatment is based on wide incision of the soft parts, affording complete access to the diseased area. It is planned by a knowledge of the most advantageous anatomical approach to the diseased bone rather than by the position of the sinus. The new-formed bone is cut away freely over the focus of infection and no attempt made to remove a sequestrum until it is exposed throughout its whole length. Breaking sequestra and leaving behind fragments is a disaster. The attempt is made to cut away the bone in such a way that the resulting gutter or trough has shelving sides.

There is a general agreement on these principles. It is advised by Baer as a preliminary to the introduction of maggots. There is a distinct advantage in waiting until the X-ray shows the dead bone detacher from the living. If the attempt is made to remove the necrosed bone before it is detached (I am speaking of staphylococcus osteomyelitis) much sound bone may be sacrificed. It is astonishing to compare X-ray pictures of reacting bone during the earlier stages of infection with the same bone some months later. The irregular deposit of lime salts in the newly formed bone, shown by lessened density and irregular mottling of the shadows, and the alteration of contour suggest a widespread lesion, but the same bone two or three months later may show a nearly normal contour and a small sequestrum readily removed by a simple operation. The most distressing cases that have come to my attention have been those in which ill-advised attempts have been made to remove most of the reacting new-formed bone under the impression that it was necrotic bone.

In circumscribed abscess in bone, it suffices to cut away the bone over the abscess, making sure that the opening in the bone is as large, if not larger than the cavity itself.

The rigid walled cavity left in bone after any of these operations requires

treatment according to the size of the cavity, its position in the bone and the virulence of the infection. Small cavities with attenuated infection heal rapidly and soundly, and remain healed after an exit is made for the exudate.

Larger cavities are best treated by some effort to obliterate the walls and allow the soft parts to fall in. Large cavities near the joints usually made by the surgeon scraping away healing bone are extremely difficult to close. Experience gained in a somewhat different field (I refer to infected gunshot wounds) shows satisfactory closure by pedicle flaps turned into the cavities, first prepared by reducing the surface infection. I have reported elsewhere the results of the treatment of bone cavities.²⁰

My experience, derived from 200 or more patients that have come under my observation of all varieties of hematogenous osteomyelitis, has led to the belief that the majority heal rapidly and permanently under suitable treatment. I have watched some of these patients for fifteen and twenty years. I have seen them grow to manhood, engage in sports where the originally diseased area is subjected to repeated trauma. The recurrences I have had have resulted from obvious failures on my own part in carrying out the simple principles involved. I have broken and left behind fragments of sequestra; I have had superficial necrosis of skin and recurrent superficial infection of underlying bone in areas where the skin has become adherent to the bone, from badly planned scars. I have delayed so long to remove a sequestrum that the density of bone made it very difficult to detect and remove a small focus of infection causing recurring infection.

I have frequently been unwilling to advise operation in adults with slight persistent lesions without disturbance of general health and with trifling disability where the operation required would demand wide exposure and prolonged incapacity. I have at times been hindered from making suitable exposure by timidity. Fear of spreading infection where the pelvic bones were involved or the occipital bone near the foramen magnum, for example, has made me temporize rather than attempt a radical operation. I have seen many so-called recurrences due to infection in other bones, or portions of the shaft beyond the original focus. I have seen several instances of the sudden awakening of infection at the site of the original lesion, years after the original lesion, in one instance thirty-six years.²⁰

Purulent collection beneath the periosteum or in the substance of bone in acutely ill children with general staphylococcus septicæmia is treated most advantageously by giving exit to the purulent exudate at the earliest possible moment and by the simplest means. During the stage when the acute stage is subsiding, during the establishment of residual lesions, every effort is made to detect and drain local collections of pus, not only at the site originally, but in other bones, soft parts, *etc.*

In most instances, one or more operations are necessary before attempting to treat the residual lesions and such residual lesions often heal under the simplest treatment. The removal of a detached sequestrum results, usually, in a rapid and permanent cure.

Therefore, the number of operations does not carry with it, necessarily, the implication of inadequate treatment. So-called radical operations on an infected bone in a young child suffering from generalized staphylococcus or streptococcus infection with the idea in mind of avoiding all subsequent operations is thought ill-advised by all who have had experience with this phase of osteomyelitis. Dean Lewis, in his paper on acute osteomyelitis, already referred to, emphasized this point by recalling the interesting experience of Wilms and Enderlen at the Heidelberg Clinic.

The cure of chronic osteomyelitis cannot be considered extraordinary if it consists of the early removal of a free and readily accessible sequestrum; many such patients heal with astonishing rapidity. A few heal by spontaneous emergence of the sequestrum without operation.

A careful statistical study of osteomyelitis made forty years ago by Haaga²² from 407 patients treated at the Bruns Clinic is interesting. The localizing in the long bones, the frequency of multiple localizations and the outcome are all tabulated. These records agree in general with observations made by all those who have considered the subject. The number of multiple lesions was considerable. There were 559 bony lesions observed in the 407 patients; of the 559 lesions only forty-nine healed without necrosis; of the 490 in which necrosis occurred, only forty-seven healed by spontaneous emergence of the sequestrum. The different bones behaved differently in this respect; ten times in fifty-five cases a sequestrum of the humerus discharged of itself, but this occurred only five times in the femur in 157 cases and only thirteen times in the tibia in 225 cases. In forty-seven, operations were not performed for various reasons. Four hundred and twelve of the 490 patients are reported as healed after the operation (84 per cent.).

To judge results in chronic osteomyelitis is difficult. It is well to remember, before drawing conclusions of any method of treatment, that hematogenous osteomyelitis is but one of the localizations in bone of a generalized infection, and that necrosis is not a disease; it is but the termination of a great number of infectious lesions of bone.

I find it confusing to include among cases of hematogenous pyogenic osteomyelitis, tuberculosis of bones and joints, and compound fractures, just as I should find it confusing to include syphilitic osteomyelitis. Each of these types of infection presents special features and demands separate consideration.

Tuberculosis of bones and joints represents localization with destructive lesions and marked general resistance. They are metastatic or tertiary lesions. Not infrequently, these focal lesions heal under simple measures: By exposure to sunlight, immobilization alone, various operations producing ankylosis of joints with incomplete excisions of the tuberculous focus, and so-called complete excision of the focus are followed by cure. All who have had considerable experience with this group of lesions agree in making every effort to avoid secondary pyogenic infection. This is as true after operations on the bones and joints as after the removal of a tuberculous kidney or uterine tube, or after operations for tuberculous peritoneum or after the

excision of a tuberculous gland. The body cells seem to take care of the residual tuberculosis inevitably left, even after the most painstaking operation, far better if the tissues are not superficially infected with pyogenic organisms.

Doctor Baer's list includes six reports of tuberculous lesions, Nos. 3, 34, 36, 47, 75 and 83. There was one death from tetanus; two are reported unimproved; 50 per cent. are reported cured.

As we all know, in a compound fracture, there is a wound of the soft parts which communicates with the broken bone. Such a wound may not be soiled with the pathogenic bacteria, or the bacteria may be few in number, or the wound may be heavily contaminated. A compound fracture is by no means necessarily followed by traumatic osteomyelitis; many heal like a simple fracture without any established infection in the broken and damaged ends of the bones. Here again, every effort has been made for the last sixty years to avoid introducing new pathogenic bacteria after the injury.

Doctor Baer's report includes seven cases classified as compound fractures, Nos. 45, 48, 51, 54, 56, 78 and 81. All seem instances of traumatic osteomyelitis. In Case 48, however, the patient came under treatment four days after the injury; the infecting organism was reported as the staphylococcus, but there is no mention of whether cultures were taken from the bone or the wound in the skin. Four are reported healed, three improved. In Nos. 51 and 54, there is no record of the introduction of maggots.

The treatment of compound fractures by this method brings up a curious confusion in both of Doctor Baer's papers regarding secondary infection, the relation of antiseptics to infection and the reason for the use of antiseptics and of materials sterilized by heat as applied in modern technic, and the distinction between a contaminated wound and an infected wound.

Doctor Baer writes: "Nothing was used upon the skin of the patient except some slight scrubbing with normal salt solution, and no antiseptic whatever was brought in the neighborhood of the wound. The operation was done with bare hands, washed only in water, and while no gloves were used, no iodine or any other chemical preparation was applied to the wound itself before operation. The idea was that if the wounds healed up by means of the introduction of the maggot, the maggot alone would be responsible for the cure and no chemical agent could be said to have had anything to do with the result; and, if the wound healed, the maggot would not be injured or its activity decreased by bringing it in contact with any chemical substance."

The impression conveyed seems to be that the sterilization of the skin of the patient with an antiseptic and the wearing of gloves sterilized by heat might, in some way, invalidate the results of the maggot treatment. But it is generally recognized that these measures are not taken with any notion of the effect of chemicals on deep-seated, established infection. One would, in fact, by operating with bare hands not thoroughly cleansed, through unsterilized skin, be far more likely to confuse the issue of any given therapeutic measure through the danger of introducing in this way strains of virulent streptococci, tetanus bacilli, *etc.*, not in the original focus. He seemed to have believed that antiseptics were applied to destroy microorganisms long established and living in the walls of the reacting tissue. He seemed to have failed to distinguish between the use of antiseptics to limit or prevent the introduction of new virulent microorganisms from without, with the application of antiseptics to control established infection.

Early in the war, all efforts to disinfect the contaminated tract of missiles with chemicals were recognized as futile. It had been proved experimentally by Muller²³ and Koller²⁴ seventeen years before the war.

Nor were antiseptics such as Dakin's solution, for example, introduced with the idea of sterilizing the deeper tissue. They were introduced to wash away dead leucocytes, detritus, shreds of tissue, *etc.*, after a thorough surgical excision of the entire surface of the contaminated wound to the depth of two millimetres. It was well recognized and set down in the book on infected wounds by Carrel and Dehelly,²⁵ the exponents of the disinfection of wounds by neutral solution of sodium hypochlorite, that no matter how many times the bacteria were washed away, they would rapidly spread again over the entire wound surface as long as particles of necrotic tissue or infected foreign bodies remained. All who have studied the subject have reached the same conclusion. They were measures used to help the natural cleansing of an open, contaminated wound. Equally satisfactory results, however, were obtained by Douglas, Fleming and Colebrook²⁶ by flushing with 5 per cent. salt solution.

It has long been recognized and set down in text-books that no wound with established infection and no metastatic focus can be disinfected by a chemical solution. "The microorganisms are in the reacting tissue and beyond the reach of a chemical."²⁷

It may be well to recall that after a collection of pus has been evacuated or a sequestrum removed and after all the diverticulæ and communicating cavities have been opened, and a suitable exit made for wound discharge, a condition is created, favorable for the local defense reaction, but in most instances there are still innumerable microbes on fragments of attached necrotic tissue, in minute cracks and crevices in the infected surface. Moreover, there may be a delicate balance between the local defense reaction and the living microbes still in the zone of reacting tissue which can be readily turned one way or another.

The flow toward the surface of lymph and active living phagocytic cells, on which the destruction of bacteria in the walls of an infected cavity depends, the activity of cells which are concerned with separating the dead tissue from the living, the amount of destruction of leucocytes on the surface, with liberation of tryptic ferments so that the balance between the antitryptic and tryptic properties of the wound secretion are not disturbed, are all of great importance to maintain. Usually all is set right by the evacuation and maintenance of a free exit for wound discharges. To promote and hasten the cleansing of the infected wounds, after these essential conditions have been established, is the aim of the various ancillary measures.

The subject of infection of granulation or the infection of flowing discharges of an open contaminated wound was carefully studied during the first years of the war by Sir Almroth Wright.²⁸ He showed that the lymph-like discharge of an infected wound, when first poured out, contained mostly streptococci and active phagocytic cells, but that after it had collected in the

wound it was an opaque exudate presenting the usual characteristics of pus. The chief bacterial agents at work were the streptococci, staphylococci and the *Bacillus proteus*.

The factor that comes into play in the change of the appearance of the exudate is the amount of tryptic ferment liberated by the disintegrating leucocytes. In other words, there is a trypsin-like ferment working in an alkaline medium in all open suppurating wounds.

The original observations of Doctor Baer on which he based his ideas were drawn from seeing two wounded soldiers recover who had been without aid for seven days. I will give the story in his own words. "Two soldiers with compound fractures of the femur and large flesh wounds of the abdomen and scrotum were brought into the hospital. These men had been wounded during an engagement and in such a part of the country, hidden by brush, that when the wounded of that battle were picked up they were overlooked. For seven days they lay on the battlefield, without water, without food and exposed to the weather and all insects which were about that region. Upon their arrival at the hospital I found that they had no fever and that there was no evidence of septicæmia or blood poisoning. Indeed, their condition was remarkably good, and if it had not been for their starvation and thirst, we would have said they were in excellent condition. . . . On removing the clothing from the wounded part, much was my surprise to see the wound filled with thousands and thousands of maggots, apparently those of the blow fly. The maggots simply swarmed and filled the entire wounded area. The sight was disgusting and measures were taken hurriedly to wash out these abominable looking creatures."

Unfortunately, no distinction is made, in the description, between the wounds of the two soldiers. They are described as if they were similar. There is no mention of the type of projectile; whether the injury was caused by fragments of shell casing, by a rifle bullet, by metallic splinters from an exploding hand grenade, shrapnel ball or secondary projectiles hurled into the tissue by bursting shells such as stones, splinters of wood, *etc.*, is not recorded. There is no description of the wound of entrance or the wound of exit. The injuries are simply referred to as compound fractures of the femur. The wounds were covered with maggots. When the maggots were washed away the granulations were pink, even and healthy-looking.

I think many who have had an opportunity to treat infected wounds in large out-patient departments have seen on rare occasions wounds infested with maggots. The few instances I have seen bear out exactly Doctor Baer's statements. I remember many years ago seeing a granulating wound of the external surface of the arm. When the filthy dressings were removed, saturated with decomposing wound discharges, the surface was found covered with maggots; the granulations were pink and healthy-looking. Several of the papers that have appeared during the last year have referred to records of the older surgeons telling of the good appearance of the granulations when the wound was infested with maggots.²⁹

The explanation that has seemed to me most reasonable is that the female flesh fly laid her eggs after a sufficient barrier of leucocytes and granulations had formed to prevent infection of the surface by the microorganisms on the feet and proboscis of the fly. It is well to keep in mind how rapidly this protecting wall forms in an open wound, so that bacteria falling into the wound after ten or twelve hours, if there is no interference with wound discharge, may live and multiply on the wound discharges and the detritus on the superficial granulations but do not penetrate the deeper tissues. The experiments of Giani³⁰ are interesting in this connection. He made open wounds in animals, very susceptible to anthrax. Filter paper soaked in virulent cultures of anthrax bacillus was laid on the open wounds, as gently as possible. All the animals died if the infected filter paper came in contact with the wound under six hours; after twelve hours, they all lived. Between six and twelve hours, half lived and half died. In those that died, slight hæmorrhage indicated that the protecting wall had been mechanically broken in placing the filter paper.

The adult flesh fly, like the house fly, is "more or less bristly and well capable of carrying microorganisms from putrescent or semi-liquid substance, but the mouth parts and feet are especially adapted to the purpose." Female flies must have deposited their eggs on the open wound surface in the soldiers referred to by Doctor Baer. They must have walked over the wounds palpating with their proboscis and feet, seeking a suitable place for the introduction of the ovipositor. The female flesh flies passed their pupal state, probably, in the superficial soil of the field of battle. They developed from maggots feeding on neighboring cadavers. The proboscis and feet and the bristly hair of the body of the female fly were probably soiled with the bacillus of Welch, the tetanus bacillus as well as innumerable bacteria of decomposition. I should draw the conclusion that the original wounds inflicted in these instances had not been heavily contaminated and the flies had crawled over the wound a sufficient time after injury to have avoided secondarily infecting the wound. I should assume that the maggots, by consuming the detritus and dead leucocytes, had indeed furthered the clearing of the wound, but that the two soldiers referred had escaped infection in spite of the flies. I do not believe that "the maggots had saved the lives of those two people and had acted as disinfecting agents."

Flies, hatched in excreta of man or animals (such as house flies), or in putrefying cadavers (such as flesh flies) and alighting on fresh wounds, have justly been considered the most dangerous of all the disseminators of pathogenic microorganisms. That these facts came finally to be recognized by Doctor Baer and his associates is made evident by their efforts to rear sterile maggots. It seems very improbable that the flies that laid their eggs or the maggots that hatched in wounds of soldiers left out on the field of battle were sterile.

In conclusion, it is safe to say that the maggot of the flesh fly is not a

"Viable Antiseptic"; it multiplies and flourishes in some sort of symbiotic relation with the myriads of bacteria under natural conditions.

Its mouth parts are adapted only for taking fluid or pap-like nourishment. It cannot "gnaw bone like a dog," and no evidence has been presented that "the maggot has intuition as to where the line of demarkation is going to appear and eats down to that line and thus removes all potential sequestra."

In the conclusion in the last paper on the subject, the maggot treatment is not even spoken of as a treatment of osteomyelitis. It is said to be "a tremendously useful adjunct to thorough surgical treatment for chronic osteomyelitis, and, in our opinion, far more successful in securing permanent healing of these extensive wounds than any other method tried by us."

But no evidence is presented in the case records of the greater efficacy of this method of treatment. The records show far lower percentages of cures than are reported by the Orr treatment or than were reported forty years ago by Haaga.

The enthusiasm generated by the paradox that two severely wounded men, left untreated on the field of battle for seven days, recovered, seems, possibly, to have led to undue fervor in advancing an ancillary measure that might be used to promote the healing of a contaminated wound and that seems to have no essential relation to the cure of osteomyelitis.

ACUTE STAPHYLOCOCCUS AND STREPTOCOCCUS HEMATogenous INFECTION WITH OSTEOARTHRITIC LOCALIZATION. STAPHYLOCOCCUS SEPSIS

S. M., aged four years, eleven months, admitted April 25, 1931; discharged August 12, 1931. Diagnosis.—Acute suppurative osteomyelitis of shaft of femur. Symptoms and Findings.—Traumatic injury to knee two weeks before, followed by cold and nasal discharge; had pain in left ankle for six days; pain in knee. Diagnosed by family doctor as rheumatic fever. Temperature for past two days—104°. Physical Examination.—Slight swelling of knee; swelling and exquisite tenderness of lower femur. April 26, blood culture staphylococcus aureus hemolyticus. Wound culture staphylococcus aureus hemolyticus. X-ray Findings.—May 5, acute osteomyelitis of shaft of femur which at this time shows many destructive lesions. July 13, considerable involucrum formation; appear to be several sequestra. Operation.—Osteotomy of shaft of femur. Arthrotomy of knee-joint. Course.—Temperature on admission was 106° and ran a wavering course for forty days post-operative, then remained normal. Thirty-third post-operative day fell from chair and fractured lower third of femur. Skin traction applied. Discharged 108 days after operation in excellent condition with small draining sinus. Result.—Cured. Follow-up.—November 25, 1931, small sequestrum one inch long removed. December 9, 1931, wound well healed and walks well.

R. A., aged fifteen months, admitted August 9, 1930; discharged December 24, 1930. Diagnosis.—Hemolytic staphylococcus albus bacteremia with metastases, lobar pneumonia (group undetermined); dislocation both hips (everted dorsal); rickets; acute suppurative arthritis of hip-joints and shoulder. Symptoms and Findings.—Temperature for sixteen days; treated in outside hospital; five transfusions; but did not improve. Physical Examination.—Acutely ill septic child; infected transfusion wounds in both anti-cubital fossæ; sloughing wound in right groin; râles in both lungs; severe rickets. August 12, blood culture hemolytic staphylococcus albus. September 16, no growth in blood culture. November 26, blood culture—hemolytic staphylococcus albus (onset of pneumonia). Kahn, 0; tuberculin, 0. X-ray Findings.—August 10 bron-

chopneumonia; osteomyelitis of upper metaphyses of both humeri. January 23, 1931, review of films shows patient was originally case of severe rickets with multiple osteomyelitis. Seems probable that there were definite osteomyelitic changes present in proximal metaphysis of right tibia and both distal tibial metaphysis. At present bones show healing (complete) of rachitic lesions of left humerus at femoral heads and in distal tibiae. Lesion of right proximal tibia not completely healed. Bilateral dislocation of hips. Operation.—Transfusion 160 cubic centimetres whole blood. August 26, incision and drainage of wrist. September 5, arthrotomy of left shoulder. September 15, arthrotomy of hip-joints. September 25, arthrotomy of knee-joint. October 18, abscess of right leg incised. Course was prolonged. Developed multiple suppurative foci, all of which cultured hemolytic staphylococcus except left hip which cultured pneumococcus. Given autogenous vaccinal therapy. After fourteen weeks of septic temperature it became normal. Three weeks later developed a pneumonia in right upper and lower lobes; resolved. Result.—Cured. Subsequent History.—Wounds all well healed at time of discharge. No limitation of joint motion. Referred to Orthopedic Hospital for treatment of dislocated hips.

D. C., aged eight years and four months, admitted January 6, 1931; discharged April 1, 1931. Diagnosis.—Acute suppurative osteomyelitis of pubic bone; hemolytic staphylococcus albus. Symptoms and Findings.—December 25 fell and bruised right hip; two days later developed a boil on buttock; two days later developed pain in thigh and hip. Headache and fever with slight chill two days before admission. Physical examination showed pain on pressure and motion of head of femur (left muscle spasm). Temperature $103\frac{4}{10}^{\circ}$. X-ray Findings.—Reported negative until January 26 but review of films shows lesions sufficiently marked for diagnosis. January 6, lesion beginning in lower ramus of pubis close to synostosis of ischium. Course.—Temperature remained elevated until January 31. January 10, developed severe inguinal and femoral adenitis. (Tuberculin 1-1000 negative.) January 12, local tenderness over pubis; hip improved. January 16, hip-joint aspirated (after orthopedic opinion) clear fluid obtained. January 19, left-sided fullness on rectal examination. January 28, first reported X-ray evidence of osteomyelitis of pubis. January 31 operation. Fall of temperature to normal. Result.—Improved. Follow-up.—July 28, wound nearly healed; walks without difficulty. October 19, patient moved to Washington. No report can be obtained.

O. G., aged eleven years and five months, admitted June 2, 1931; discharged June 8, 1931. Diagnosis.—Anatomical diagnosis (autopsy):—acute periostitis of left tibia; cellulitis of lower leg; suppurative phlebitis of left saphenous vein; bacteremia staphylococcus aureus; (infarcts of lung); abscess of lungs, heart and kidneys; acute serofibrous pericarditis; acute fibrous pleurisy; bronchopneumonia. Symptoms and Findings.—Perfectly well until four days before admission then complained of pain in left thigh; no fever. Symptoms rapidly increased with headache, chills and fever. For past day, pain in left ankle with swelling and redness of leg. Temperature 105° on admission with diagnosis of acute rheumatic fever. June 6, culture of pus from wound showed hemolytic staphylococcus aureus. June 2, blood culture—staphylococcus albus. (contaminate?). June 7, blood culture—staphylococcus aureus. Operation.—June 6, incision and drainage of sub-periosteal collection of pus. June 6, transfusion 300 cubic centimetres whole blood. Course.—June 5, delirious, appears septic; leg swollen from foot to knee; red, hot and tender. No localization of abscess in leg. Pain in right elbow. June 6, patient became rapidly worse. Operation.—Collection of subperiosteal pus drained from lower third of left tibia. Result.—Died.

C. B., aged eleven years, admitted October 18, 1929; discharged October 10, 1930. Diagnosis.—Acute suppurative osteomyelitis of shaft of left tibia (staphylococcus albus hemolyticus); acute suppurative arthritis of left knee-joint. Symptoms and Findings.—Temperature, vomiting and headache for three weeks; pain and redness of both elbows for two weeks, then subsided; cervical spine and both hips became painful;

MAGGOTS AND OSTEOMYELITIS

small red spot over left tibia for three weeks, progressively becoming worse. Physical examination showed swelling of entire left leg; abscess over upper third of tibia; culture of pus from abscess and knee-joint contained hemolytic staphylococcus albus. No record of blood culture. X-ray Findings.—October 18 acute osteomyelitis of upper end of tibia. February 5, 1930, old osteomyelitis of tibia showing evidence of repair. July 8, 1931, no evidence of sequestrum. Operation.—October 18, incision and drainage of subperiosteal abscess of left tibia. November 16, arthrotomy of left knee-joint. May 8, 1930, incision and drainage of abscess of post-crural region. Course.—Cast applied to leg after arthrotomy; small sequestra removed at frequent intervals through sinus in leg. May 25, 1930, knee manipulated under anæsthesia to free adhesions. Allowed to walk with brace. July 10 lower sixth of femur fractured during manipulation of knee under anæsthesia. Result.—Improved. Subsequent History.—At time of discharge general condition was good. Had small sinus draining from tibia; walked well but had some stiffness of knee. Follow-up.—Referred for treatment to St. Luke's Hospital following discharge because of over age.

B. V., aged nine years and six months, admitted July 6, 1930; discharged October 10, 1930; readmitted December 25, 1930; discharged December 27, 1930. Diagnosis.—Acute suppurative osteomyelitis of upper third shaft of femur; acute suppurative arthritis of hip-joint; septicæmia; two abscesses. Symptoms and Findings.—Pain in right hip for five days; vomiting, fever and headache eight days; temperature 106° ; blood culture hemolytic staphylococcus albus, (at Hackensack Hospital). July 7, blood culture; no growth. X-ray Findings.—No changes apparent on admission; gradually appeared rarefied area involving trochanter and upper sixth of femur. December 16, no evidence of extension distally; evidence of articular and epiphyseal involvement. Operation.—July 19, 1930, arthrotomy of hip. Immobilized in plaster cast. Culture of pus showed staphylococcus albus. Course.—No complication. Discharged to convalescent hospital. All wounds healed. Result.—Improved. Subsequent History.—Superficial abscess of trochanteric region opened six months after first admission.

W. S., aged ten years, admitted August 3, 1930, discharged November 14, 1930; second admission February 17, 1931, discharged April 8, 1931; third admission June 30, 1931, discharged September 30, 1931; and fourth admission December 7, 1931, discharged December 11, 1931. Diagnosis.—Acute suppurative osteomyelitis of upper end of left tibia. Acute suppurative arthritis of right hip; chronic osteomyelitis of tibia; chronic osteomyelitis upper end of humerus; chronic osteomyelitis of humerus. Symptoms and Findings.—Painful left knee for eight days. Patient was struck blow in knee two weeks before; delirious past two days. Temperature 104° on admission. Blood culture. Hemolytic staphylococcus albus. Five days later hemolytic staphylococcus albus. Five days later no growth. Operation.—Osteotomy drilled. Arthrotomy fifty-four days later; sequestrectomy; incision and drainage; sequestrectomy. Immobilized in plaster after first operation. Course.—Prolonged but steady improvement. Result.—Cured. Subsequent History.—Considerable trouble with sequestra. September 19, 1931, Thiersch skin graft with good result. Follow-up.—March 2, 1932, all wounds healed. General condition good. No limitation of motion.

STREPTOCOCCUS SEPSIS

J. J., aged six months, admitted January 15, 1931; discharged March 18, 1931. Diagnosis.—Eczema, Hemolytic streptococcus bacteremia with metastases to bone and soft tissue; acute suppurative osteomyelitis; acute nephritis. Anatomical Diagnosis (autopsy)—Eczema; suppurative arthritis right ankle; bacteremia, streptococcus hemolytic. Abscess of finger, acromial, malleolar, right hip, right trochanteric and inframammary regions. Suppurative adenitis, osteomyelitis of humerus. Chronic peri-splenitis. Broncho-pneumonia. Emphysema of lungs. Symptoms and Findings.—Rash over cheeks for two weeks, spreading over face and scalp. Profuse diarrhœa and vomiting for one week. Parents luetic. Temperature $103\frac{1}{2}^{\circ}$ on admission; acute otitis media. January 26—

fontanelle full; spinal fluid negative. January 27, right ankle drained; hemolytic streptococcus. January 30—blood culture, hemolytic streptococcus. February 2, proximal phalanx of left index finger drained; hemolytic streptococcus. February 4, abscess of shoulder drained; hemolytic streptococcus. February 7, erysipelas of left buttock and thigh; abscess of ankle drained; hemolytic streptococcus. February 11, five cubic centimetres erysipelas antitoxin. February 13, erysipelas faded. February 14, abscess of parotid region. Right thigh swollen; hip motion restricted. February 15, abscess of elbow drained. February 21, right hip drained; hemolytic streptococcus. March 3, abscess of knee and of thoracic wall drained; hemolytic streptococcus. Became steadily worse and died. X-ray Findings.—Osteomyelitis proximal metaphysis of left humerus. February 16 osteomyelitis of metaphysis of femur. Destructive changes present in proximal portion of right radius and ulna. Operation.—Multiple incision and drainage. February 3 transfusion 100 cubic centimetres whole blood. Result.—Died.

F. S., aged fifteen months, admitted December 27, 1931; discharged January 27, 1932. Diagnosis.—Acute suppurative osteomyelitis of humerus (hemolytic streptococcus). Symptoms and Findings.—December 25, sudden onset of irritability and fever. Tenderness of left arm. Temperature 104°. December 27, definite weakness of left arm; admitted as possible poliomyelitis. Physical Examination.—Left arm painful below shoulder. Spinal fluid negative. December 28 temperature 105°, swelling and slight redness with firm mass felt along outer side of mid-humerus. Blood culture. December 28, hemolytic streptococcus. X-ray Findings.—December 28, no bony changes, January 23, considerable involucrum. No sequestrum. Operation.—Osteotomy. December 29, pus from bone, hemolytic streptococcus. Course.—Uneventful. Result.—Cured. Subsequent History.—None. Follow-up.—March 3, 1932, wound soundly healed. Free motion of arm.

W. H., aged nine months, admitted March 19, 1930; discharged April 11, 1930. Diagnosis.—Bronchopneumonia (group undetermined), hemolytic streptococcus, bacteremia with metastases, acute osteomyelitis of humerus, suppurative arthritis of shoulder. Symptoms and Findings.—Admitted with diagnosis of bronchopneumonia and possible poliomyelitis (later excluded). March 20, definite signs of arthritis of shoulder-joint. Blood cultures, March 19, 21, 23 and 24 grew hemolytic streptococcus. March 26, negative. X-ray Findings.—March 20, evidence of bone involvement of upper humerus. Operation.—March 24, arthrotomy; pus—hemolytic streptococcus. Transfusions on March 20, eighty cubic centimetres; March 21, ninety cubic centimetres; March 22, eighty cubic centimetres; March 24, eighty cubic centimetres; April 4, eighty cubic centimetres. Course.—Following arthrotomy, shoulder lesion promptly healed. Temperature flat for seven days. Good motion of joint. Blood culture negative. Result.—Cured. Subsequent History.—Readmitted April 23, 1930, had arthritis of left hip with dislocation. Joint explored. No pus found; no sequestra. Hip reduced and maintained. Developed measles and discharged June 18. Follow-up.—Motion good in both shoulder- and hip-joints. August 17, no deformity. Stands but has not walked (fourteen months old). No further follow-up; family cannot be found.

L. D., aged four months, admitted January 17, 1930; discharged March 15, 1930. Diagnosis.—Acute suppurative arthritis of hip- and shoulder-joints; furunculosis; acute otitis media; bacteremia with metastases. Symptoms and Findings.—Fever; crying as if in pain for five days; swelling of left thigh for three days. Temperature subsided after drainage of hip but rose again two weeks later and shoulder became swollen; drained; developed severe furunculosis. These were drained and patient given autogenous vaccine. January 18 and 21, blood culture, hemolytic streptococcus. February 12, blood culture negative. X-ray Findings.—January 18, 1930, considerable widening of the joint space of left hip with swelling of soft tissues of left thigh. Appearance suggestive of purulent arthritis. November 25, 1931, lateral dislocation of head of left femur. No evidence of osteomyelitis. Operation.—January 18 arthrotomy of hip; twenty cubic centimetres pus—hemolytic streptococcus. February 4, arthrotomy of shoulder—ten cubic centimetres

MAGGOTS AND OSTEOMYELITIS

metres pus. January 21, transfusion, ninety cubic centimetres whole blood. Course.—All wounds healed at time of discharge. Result.—Improved. Follow-up.—November 18, 1931, walks with slight limp. Has $\frac{1}{4}$ inch shortening of leg. Arm well healed with good function of shoulder. Referred to Orthopedic Hospital for reduction of dislocated hip.

S. F., aged four months, admitted April 18, 1930; discharged June 14, 1930. Diagnosis.—Abscess of lateral femoral region; hemolytic streptococcus bacteremia with metastases. Acute suppurative osteomyelitis of upper extremity of tibia. Acute arthritis of knee-joint. Measles. Symptoms and Findings.—Fever, rhinitis, irritability, for two weeks. Swelling of left thigh and edema of leg for one week. Temperature 101° - 102° . Blood culture on admission showed hemolytic streptococcus. X-ray Findings.—Purulent osteo-arthritis of tibia; probable epiphysitis of upper tibial epiphysis. Operation.—April 19, drainage of thigh abscess. May 13, arthrotomy left knee. Both cultured hemolytic streptococcus. Course.—Following drainage of thigh abscess, erysipelas developed in wound; 15,000 units antitoxin given. Result.—Infection cured. Some residual knee contracture. Subsequent History.—Developed measles, June 12. Follow-up.—Some flexion contracture of knee. All wounds well healed.

A. D., aged ten months, admitted July 31, 1930; discharged September 2, 1930. Diagnosis.—Acute suppurative osteomyelitis of lower extremity of fibula; hemolytic streptococcus bacteremia with metastases. Symptoms and Findings.—Fever for five days; one convulsion; for four days temperature was 104° - 106° . For three days had a painful left leg. Both blood and wound cultures showed hemolytic streptococcus. August 13 blood culture showed no growth. No X-ray findings were reported. Operation.—Incision and drainage. Bone drilled and wound packed with vaseline gauze. Course.—Normal; discharged thirty-two days after operation with slight drainage. Developed furuncle on hand ten days after operation with culture showing hemolytic streptococcus. Result.—Improved. Follow-up.—February 15, 1932, wound well healed. Has been treated at Orthopedic Hospital where X-rays were said to show small sequestra.

BIBLIOGRAPHY

- ¹ Baer, W. S.: Viable Antiseptics in Chronic Osteomyelitis. Proceedings of the Interstate Post-Graduate Medical Association of North America. Detroit, p. 370, 1929.
- ² Surgical Maggots, Lederle: Jour. Am. Med. Assn., vol. xcvi, p. 401, (New and Non-official Remedies), 1932.
- ³ Lewis, Dean DeWitt: Proceedings Interstate Post-Graduate Medical Association, p. 269, 1929.
- ⁴ Science News Letter, vol. xx, p. 122, 1931.
- ⁵ Daily Star, Long Island City, May 11, 1932.
- ⁶ Baer, W. S.: Treatment of Chronic Osteomyelitis with Maggots. Jour. Bone and Joint Surg., vol. xiii, p. 438, 1931; arranged for publication by G. E. Bennett.
- ⁷ Fabre, J. H.: Souvenirs Entomologiques (Dixième Série) La Mouche Bleue de la Viande-Le Ver., p. 259; La ponte, p. 241.
- ⁸ Guyénot, E.: L'Appareil digestif et la digestion de quelques Larves des Mouche. Bul. Scientific de la France et de la Belgique, vol. xli, pp. 353-369, 1907.
- ⁹ Howard, L. O.: The House Fly, p. 22, 1911.
- ¹⁰ Imms, A. D.: A General Text-book of Entomology, second edition, p. 103, 1930.
- ¹¹ Woolman: Biologie de la Mouche Domestique et des Larvae de la Mouche a Viande. Annals Institut Pasteur, vol. xxxvi, p. 784, 1922.
- ¹² Hopson, R. P.: Studies on the Nutrition of the Blow-fly Larvæ. Jour. Experimental Biol., vol. viii, p. 109, 1931.
- ¹³ Kalowski, J.: Orr Treatment of Osteomyelitis. Jour. Bone and Joint Surg., vol. xxix, p. 538, 1931.
- ¹⁴ Lannelongue, and Archard. Etude expérimentale des ostéomyélites a Staphylocoques et a streptocoques. Annals de la Institut Pasteur, vol. v, p. 209, 1891.

- ¹⁵ Colzi, F.: Sulla Etiologia della osteomyelitis Acuta. *Lo Sperimentale*, November-December, 1889, vol. lxiii-lxiv, pp. 471-561.
- ¹⁶ Lexer: Beitrage zur Lehre der Osteomyelitis Acut., *Archiv. f. Klin. Chir.*, vol. xlviii, 1891.
- ¹⁷ Wyssokowitsch: Ueber das Schicksal der im Blut injizierten Microorganismen im Korper der Warmblüter. *Ztschr. f. Hyg.*, vol. i, p. 3, 1886.
- ¹⁸ Hobo, T.: Pathogenesis of Osteomyelitis. *Acta Scholae Med. Univ. Imp. Kioto*, vol. iv, p. 1, 1921 (Comp. Bibliography).
- ¹⁹ Lannelongue, and Comby, J.: Osteomyelitis chronique ou prolongee. *Archiv. Générales de Medeciano*, vol. ii, pp. 257, 424, 555, 681, 1879.
- ²⁰ Martin, Walton: Treatment of Bone Cavities. *ANNALS OF SURGERY*, vol. lxxi, p. 57, 1920.
- ²¹ Martin, Walton: The Results of Staphylococcus Infection of Bone. *Surg. Clin. N. Amer.*, vol. iii, p. 409, 1923.
- ²² Haaga: Beitrage z. Klin. Chir., vol. v, p. 49, 1889.
- ²³ Muller: *Deutsch. Ztschr. f. Chir.*, vol. xlvii, p. 199, 1897.
- ²⁴ Koller: *Deutsch. Ztschr. f. Chir.*, vol. xlvii, p. 211, 1897.
- ²⁵ Carrel, A., and Dehelly, G.: *Le Treatment des plaies Inf.* Masson et cie 1917, Eng. Trans. by H. Child, Hoeber, 1917.
- ²⁶ Douglas, Fleming, and Colebrook: Wound Infections. Great Brit. Med. Res. Council, Spec. Ref. Series No. 57, 1920.
- ²⁷ Martin, Walton: Surgical Infection. *Lewis Surgery*, vol. i, p. 458.
- ²⁸ Wright, Sir Almroth: Wound Infection. Univ. of London Press, p. 7, London, 1915.
- ²⁹ Goldstein: Maggots in the Treatment of Wounds and Bone Infection. *Jour. Bone and Joint Surg.*, vol. 13, p. 476, 1931.
- ³⁰ Giani, R.: Ueber die Frage der Widerstandsfähigkeit der Granulationen dem Nulzbrand gegenüber. *Centralbl. f. Bakteriologie*, vol. xl, p. 238, 1905.

FRACTURE OF THE NECK OF THE FEMUR

CLINICAL CRITERIA IN PROGNOSIS

BY KELLOGG SPEED, M.D.

OF CHICAGO, ILL.

THIS report seeks to expose practical points in the treatment of fractures of the neck of the femur, laying stress on two factors based on a study of clinical and laboratory material which may be used as criteria in prognosis. Intertrochanteric fracture of the femur is excluded, because it is not similar in reaction and result and because it was covered in a report made by me after a study of 120 cases.

Briefly, to recall the orthodox steps in treatment of fractures of the neck of the femur, based largely on Whitman's work in 1890, we expect to put the patient through manœuvres which include pulling the leg out to full length, inverting it to bring bony contact between fractured surface of the head and trochanteric portion, abduction to the fullest extent to jam the bony surfaces together and to hold them impotently in that reduced position, the whole followed by immobilization in a proper dressing, usually plaster-of-Paris, until bony union has been secured, and motion, weight-bearing and functional use may follow.

It is possibly needless to vouch for the simplicity and potential accuracy of this accepted method of treatment. Various collections of so-called end-results in series of patients thus treated are recorded in the literature. From the Massachusetts General Hospital we learn that there are 60 per cent. of successful outcomes from this treatment in a small group of cases. Whitman himself, Hey-Groves, Campbell, Stern and others give grouped results with and without making statements covering the varying percentages of cures. In spite of really great advance in the treatment of this major peripheral fracture of the skeleton some men have persisted in studying the situation further, not necessarily on account of the approximately 40 per cent. of untoward results, but to better fracture-treatment situation as a whole and to stimulate renewed interest and actual exposure of just what goes on during the healing or failure to heal of a fracture of the neck of the femur. Among other contributions have been those of Reggio, Santos and Phemister. Two of my own contributions were in 1924 and 1928.

The two points I wish to bring out now as clinical criteria in prognosis which may help also in treatment can be employed whether the method applied has been nonoperative or operative, provided the customary rules of fracture treatment have been followed, namely, apposition, rest, immobilization.

These two factors are: (1) Has the head of the bone retained its vitality or is it undergoing aseptic necrosis with or without substitution of bone;

(2) are the supporting bony trabeculae in the head and neck reforming to give proper weight-bearing support and lasting function. The second factor undoubtedly depends on the first; the two taken together afford a clear expression as to the prognosis of union and the future use of the leg.

After fracture of the neck of the femur a certain amount of aseptic necrosis of bone, followed by invasion with osteoid tissue, develops across the fracture plane and extends backwards into the cancellous bony tissue of both fragments for a varying distance. If the fracture is early reduced and held in position as in the orthodox treatment, does bony union always follow? Unfortunately, no. Union may not follow even when the apposition or reduction is enhanced by natural impaction or Cotton's artificial impaction, or by open operation which freshens bony surface and insures exact apposition under the surgeon's eye, or is supported and possibly physiologically aided by a bone transplant or drill holes inserted across the fracture plane. So much seems to depend on the viability of the head, its retention of sufficient blood supply from its periosteal, capsular or ligamentum teres vessels to maintain itself alive. This principal fact is necessary to insure stable and lasting bony union to the trochanteric fragment, the avoidance of flattening of the head, ununiting fracture, and delayed breaking down of the bone with aseptic necrosis. If this blood supply is insufficient various parts of the head, deprived of nourishment, will die. Such dead heads retain their original density and bear a striking contrast in the röntgenogram to the surrounding bone of pelvis and femur which undergoes loss of calcium salts incidental to the enforced rest from use after fracture and immobilization. The head dying or dead shows a deeper X-ray shadow in those parts affected. It may be possible for a vigorously vascular trochanteric fragment to build up osteoid tissue and really unite with a head, dead for the most part. But this union will not be stable nor lasting when it is subjected to the test of functional use and weight-bearing.

If the head fragment dies, undergoes aseptic necrosis in whole or in part, a reestablishment of vascular supply, a carrying in of new vessels and an absorption of dead bone and a rebuilding of new bone may eventually furnish the patient with a viable, well-formed bony head which will tolerate all the requirements of use. That process takes time and leads to the second or mechanical point I wish to make.

After any fracture followed by annealing callus formation a rebuilding and refining of the callus must ensue before a final stage of healing of the fracture is established. Nowhere is this slower, more necessary nor more important than in the neck of the femur. This rebuilding of newly formed callus or bone from osteoid tissue in the neck of the femur is shown by a realignment of the bone trabeculae which are the underlying bridge work of the bony structure which give the support required for the stresses of use. Long after the deposit of calcium salts as callus or new bone has reached an end stage, this refining and trabecular rebuilding must go on until the

FRACTURE OF THE NECK OF THE FEMUR

architectural structure of the bone in the neck of the femur assumes mature form and is capable of carrying on the work of use. One can study this architectural arrangement in the normal neck of the femur to familiarize one's eye with the directions of the trabecular lines and thus be prepared to compare with the normal the process as shown in the röntgenogram (Figs. 1 and 2) of a given case after a fracture of the neck of the femur. Once the trabeculae are thoroughly and maturely reformed, the observer is confident that the bone will stand use, and that weight-bearing can safely be undertaken by the patient. No nonunion, no ununiting of the healing frac-

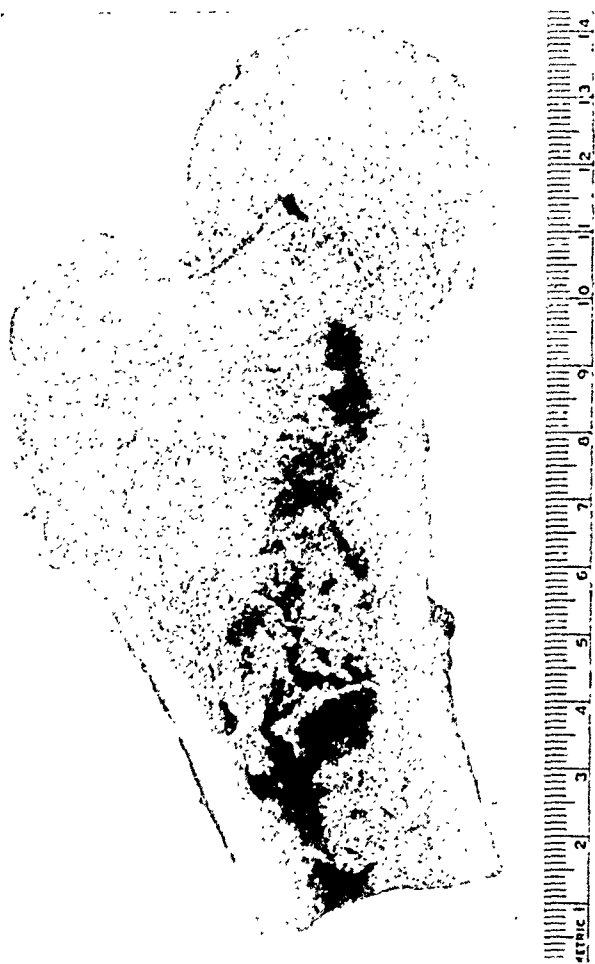


FIG. 1.



13056

FIG. 2.

FIG. 1.—Autopsy specimen of impacted fracture of the neck of the femur three weeks after the accident. The cartilage on the head shows no gross change, the bone in the head appears uniformly dense and its viability is indeterminable. At the fracture plane evidences of blood extravasation, revascularization are showing. In the trochanteric portion of the diaphysis are evidences of hyperæmia and blood extravasation. All vascular and bone changes in these areas are slow in development.

FIG. 2.—X-ray film of the specimen shown in Fig. 1 three weeks after fracture. The plane of fracture is slightly impacted. The well-defined trabeculae in the head mesh into those of the diaphysis which are far less well defined, but angulate sharply at the level of contact. In the diaphysis is apparent bony absorption, extending up toward the plane of fracture. At the exact plane of fracture appears heavy bone shadow as if the bone were dead and starting to undergo absorption. The deep clear shadows of the head might lead one to suspect three weeks after fracture that the head was largely dead.

tured neck of the femur is going to take place in the face of that finding when increasing graduated use and weight-bearing demonstrate no röntgenological change in trabecular alignment. X-ray control (Figs. 3 and 4), however, at suitable short intervals must depend on the reaction of the bone within itself to the physiological requirements it has to meet. Hence factor

two, this trabecular realignment, must depend on factor one, a retained vitality and blood supply of bone in the head and fracture region.

Chandler, of Chicago, has studied the blood-vessels of the ligamentum teres to find that in 112 ligaments removed from sixty-five cadavers all showed definite blood-vessels in this ligament, some as large as 1.3 millimetres in diameter. On section, four of the ligaments were classed as avascular because only very small vessels were present; eight ligaments contained a large number of small vessels, thirty-six ligaments contained vessels less than half a millimetre in diameter. A group of forty-eight ligaments contained vessels from one-twelfth to one millimetre or greater in size. The

ligamentum teres vessels in every case were shown to have connections with those in the head of the femur and it must become an accepted surgical fact that these vessels are normal, constant, and



FIG. 3.

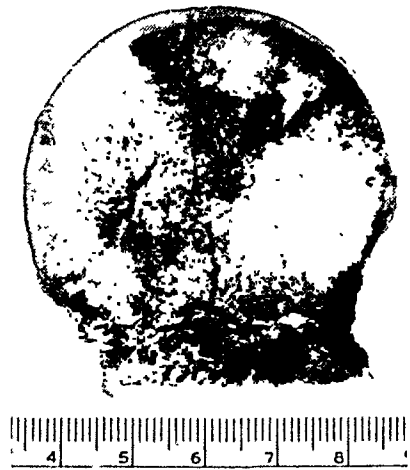


FIG. 4.

FIG. 3.—Another autopsy specimen four and a half months after fracture. The dense shadow in the centre of the head leads to the impression that bone there is dead. Union at the fracture site is not apparent. There is great absorption of calcium on the diaphyseal side. Loss of bony shadow on the edge of the head leads to a supposition that bone absorption or replacement is going on there from blood supply furnished from ligamentum teres vessels.

FIG. 4.—A wafer section through this head and fracture shown in Fig. 3 four and a half months after fracture. The whitish thick areas in the head represent dead bone, deprived of blood supply. The darkened areas represent invasion by blood-vessels and replacement or absorption of the old bone. The fracture is plainly ununited, the bony trabeculae across the fracture in the neck have not reformed at all.

important in sustaining viability of the head of the femur (Figs. 5 and 6) after fracture along with the other sources of blood supply to the head and neck arising from the capsules of the joint, the periosteum or the extended blood supply of the diaphysis originating from the superior nutrient artery of the femur.

Certain other factors must be considered clinically in discussion of neck fracture.

FRACTURE OF THE NECK OF THE FEMUR

(1) The trauma of fracture may tear off the ligamentum teres or tear and injure its vessels by stretching or compressing without true rupture of the ligament so that the blood supply coming along this avenue is permanently interfered with. Traumatic thrombosis may be present.

(2) The trauma of fracture may likewise interfere with the vitality and nutrition of the cartilage on the head of the femur by pressure, later to cause death of the cartilage and invasion by the underlying bone.

There may consequently be certain heads of the femur doomed to die (Figs. 7 and 8) after fracture of the neck despite any line of treatment based on the integrity of the blood supply of the head acquired through the



FIG. 5.



FIG. 6.

FIG. 5.—Another autopsy specimen three months after fracture of the neck. The fracture has not united although impacted. The head appears quite viable. Some trabeculae seem to be lining up on the inner side of the neck but they are not in true alignment. There is here also great loss of calcium in the diaphyseal portion of the bone.

FIG. 6.—Autopsy specimen over two years after fracture of the neck. A true union has followed and one can see a complete restoration of the lines of supporting trabeculae of bone from the diaphysis up into the live head.

vessels of the ligamentum teres. The other sources of blood supply may be too scanty or may be so interfered with by fracture that aseptic necrosis of the head is inevitable, the balance of vitality in the head from the various precarious sources of supply being just sufficient to maintain nutrition under normal untraumatized conditions.

We find clinically that some heads of the femur in elderly people do break down to undergo aseptic necrosis and fragmentation in the absence of known fracture or recognized specific (but not chronic) trauma. In Legg-Perthes disease in adolescents the head likewise becomes necrotic and dead, definite trauma apparently not entering as a causative factor. In many cases of

congenital dislocation of the hip, the nucleus of the head, which may be small but not necrotic, while the dislocation is in existence, takes on new growth and may reach mature size after reduction followed by the stimulation of normal use. In such instances the ligamentum teres, though stretched, has not been torn; it may be found at operation for open reduction of these dislocations and its vessels function.

On this basis the operation devised by Hey-Groves for pegging the head of the femur onto the diaphysis via the open path of the fovea by first removing it entirely from the acetabulum and cutting away the ligamentum teres seems absolutely unwise and undesirable. Any unions after such procedures must be by chance; they may be studied long enough to represent union of the neck to a dead head which ultimately breaks down and becomes fragmented in a large proportion of the cases.

In operative treatment of fracture of the neck by insertion of an autogenous bone peg from the trochanteric side the exact angle and position of



FIG. 7.

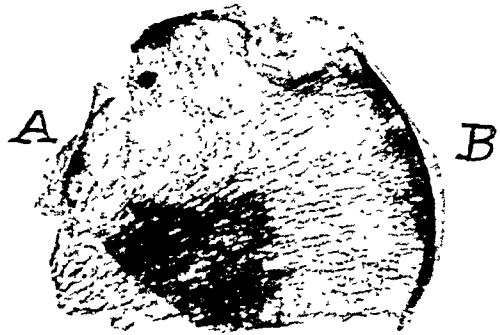


FIG. 8.

FIG. 7.—X-ray study of wafer-section head of femur removed eleven months after fracture of neck of femur in the performance of a reconstruction operation. The loss of cartilage by erosion, the loss of underlying bone substance, the uniform deep density of the trabeculae in the head and the absorption along the edge of the uneven fracture plane make it evident that the head is dead and little or no effort at revascularization of it has occurred.

FIG. 8.—X-ray study of wafer section of head of femur sixteen months after fracture when head was removed for a reconstruction operation following nonunion with much pain when weight-bearing was attempted. The fovea is plainly seen with evidence beneath it of bone absorption and replacement. The replaced bone is lighter in calcium shadow and its spaces are wider, its trabeculae finer in shadow. In areas on the head the cartilage (A) is eroded and loosened with some broken-down and dead bone beneath. In other areas of the head (B) the cartilage seems still viable with dead bone just beneath. Some of the head in lighter shadow is evidently replaced by newly formed bone, apparently taking blood supply from the fovea and near the fracture plane are found old deep shadow-producing trabeculae of dead bone of original density of the head as of the day of accident. Apparently no effort at union with the diaphysis but on the whole considerable replacement of the head by new bone. A partially alive head.

the bone peg may excite discussion. If it enters the head fragment in such a manner that it points directly into the fovea or the path of the vessels of the ligamentum teres entering via the fovea, may it shut off the scant blood supply of the head as would the peg inserted from the head side through the open fovea. For the average surgeon it would hardly be possible to avoid this direction of the peg with any certainty, even with the help of fluoroscopical control, and he would be both lucky and satisfied to get the peg well into the centre of the head.

Other points of greater refinement, concerning the function of autogenous

FRACTURE OF THE NECK OF THE FEMUR

bone pegs and the healing formation of bone after fracture must be considered in this matter. There is no known proof that under the normal condition of insertion of an autogenous bone peg any increased blood supply of the head of the femur results or that pegs inserted so as to avoid the fovea region in a series of cases, lead to sure bony union and not to a breaking down of the head fragment. If, therefore, after this fracture we feel that we should preserve every known bit of blood supply in the region, why insert any bone peg at all, especially in fresh fracture? The bone transplant may be of use as a fixation agent, the freshening of the bone surfaces of the neck and head may be the largest factor in providing new and lasting blood supply with the subsequent introduction of osteoid tissue, callus formation and eventual reconstruction into trabecular bone. I cannot see that any



FIG. 9.—Photomicrograph of fibrous replacement of dead bone of the head in another specimen removed for reconstruction operation on account of dead head and nonunion. There seems to be no effort at new bone formation even under the microscope.

modification of the technic of bone transplant, insertion or reposition as suggested by Jones in trochanteric transplantation affects the underlying physiological principles.

A microscopical study of heads of the femur which we have removed at varying periods of time (Figs. 9, 10, 11 and 12) after fracture along with study of post-mortem specimens recovered months and years after fracture seem to show that the vessels incoming via the ligamentum teres are dilated after fracture; they lead to the bringing in or development of osteoid tissue which is to form new bone. Old dead bone can be seen undergoing absorption but there is no positive evidence that new bone formed in the immediate vicinity necessarily takes its calcium supply from disintegration of the dead bone.

Can we say, therefore, that a bone transplant in the neck of the femur offers new bone or increases the blood supply or offers any physiological



FIG. 10.

FIG. 11.

FIG. 12.

FIG. 10.—Photomicrograph of section through the fovea region of the head shown in Fig. 8 (sixteen months after fracture). At A is the cartilage of the head with many viable cells. Below that at B the ligamentum teres attachment dips into the head carrying its fibrous tissue and blood-vessels. Dilatation of these vessels may be seen. At C is found newly laid down bone along the edge of the fibrous osteoid tissue fed from the fovea vessels. D is dead bone in the head not yet absorbed.

FIG. 11.—Photomicrograph of section of another area deeper down in the head showing the inspraying vascularization of osteoid tissue. A is newly formed bone; B old dead bone; C the fibrous replacement with osteoid tissue. At A, B is seen newly formed bone; at C old dead bone undergoing absorption by osteoclasts; at D washed-out medullary spaces in old dead bone. The process of absorption and replacement of old dead bone of the head is vigorously progressing from blood supply brought in through the ligamentum teres vessels via the fovea. There was absolutely no union across the neck fracture.

stimulus to new bone formation? May it not be a mechanical agent of autogenous material or may its presence excite increased vascularity which may lead to greater efforts at new bone in response to the patient's needs? If it is to be absorbed to furnish material for new bone formation why has it not done so after eight years in the film here shown, and why in spite of its insertion not truly into the fovea has the head eventually broken down, lost its contour and become aseptically necrotic in large part at least? Dead bone or bone aseptically necrosed will not react normally; live bone alone gives that final satisfactory reestablishment of trabeculæ.

Reduced to simple terms the surgeon must then be sure after fracture of the neck of the femur that

(a) The head of the femur retains its vitality.

(b) The bony trabeculæ of head and neck reform to a mature condition to be certain that his prognosis of bony union and controlled weight-bearing future is possible.

It sometimes happens that bony union after fracture of the neck of the femur goes on to an advanced stage, the head remaining viable may unite, normal trabecularization starts and then the patient is allowed unwisely to bear weight too soon. Interference with blood supply may follow and a reverse process starts up, breaking down the trabeculæ. Areas of aseptic necrosis develop in the head, an ununiting process becomes evident and what was promising to be an excellent outcome in the end terminates unhappily with deformed head, pain, bony exostoses, interference with hip-joint motion and function. This process has been described by many investigators as the much-to-be-regretted proliferating arthritis coming on after fracture.

The same process can and usually does follow union of the live trochanteric portion to a head not recognized as being dead. A poor or completely unhappy result follows. The process of bony healing and complete trabecularization must vary with the individual, dependent basically on the blood supply, the carefulness of the surgeon, the patient's weight and activity.

To aid in prognosis these two factors are therefore called to your attention. The time required for finished bony union in the neck of the femur in a given case seems to vary; no mean can be stated. In the acute epiphyseal separations of adolescents with complete restoration of position followed by prolonged immobilization and with careful inception of weight-bearing guarded by a walking caliper, I have found the head of the femur almost completely disintegrated, flattened, aseptically necrosed, after eight years. In the study of adolescent coxa vara, Jahss called attention to the frequently rotated head fragment which does not come to lie directly in contact with the trochanteric portion after Whitman's manipulation. He advises the necessity for bringing the distal part of the femur into line with this head so that contact may be assured and a poor result avoided. It is not in this type of case that I would apply the criteria of prognosis but only in the type where complete satisfactory reduction was certified. In cases of com-

plete reduction of fracture of the neck of the femur in adults the same has resulted. In perfectly clean instances of autogenous bone pegging of fracture of the neck of the femur with apparently good result, the same disintegration, aseptic necrosis, flattening of the head and cartilage-shedding process has been found years later.

It is then necessary to assay the fractures of the neck of the femur from a little different standpoint if we wish to get clearer indications for reconstruction operations and reliable statistics of the percentage of final cure. Trustworthy statistics can be obtained only when all cases are studied röntgenologically for years.

For purposes of criteria in prognosis that we may count upon to assure both patient and ourselves, these two clinical findings revealed by the röntgenological study may be taken as guides. Final results want years of observation.

BIBLIOGRAPHY

- Campbell, Willis: Ununited Fractures. *Internat. Jour. Med. and Surg.*, vol. xlv, p. 372, August, 1931.
- Chandler, Simon B.: The Blood Supply in the Ligamentum Teres and Its Relation to the Supply of the Head and Neck of the Femur. (Paper as yet unpublished.)
- Henry, M. O.: Proximal Osteosynthesis in Intracapsular Fractures of the Hip. *Jour. Bone and Joint Surg.*, vol. xiii, p. 530, July, 1931.
- Hey-Groves, Ernest S.: Treatment of Fractured Neck of the Femur with Especial Regard to Results. *Jour. Bone and Joint Surg.*, vol. xii, p. 1, January, 1930.
- Jahss, S. A.: Displacement of the Upper Epiphysis of the Femur, Adolescent Coxa Vara. *Jour. Bone and Joint Surg.*, vol. xiii, p. 856, October, 1931.
- Jones, Ellis W.: Trochanteric Transplantation in the Treatment of Fractures of the Neck of the Femur. *Jour. Bone and Joint Surg.*, vol. xiv, p. 259, April, 1932.
- Murray, C. R.: Delayed and Nonunion in Fractures in the Adult. *ANNALS OF SURGERY*, vol. xciii, p. 961, May, 1931.
- Phemister, D. B.: Repair of Bone in the Presence of Aseptic Necrosis Resulting from Fractures, Transplantations and Vascular Obstructions. *Jour. Bone and Joint Surg.*, vol. xii, p. 769, October, 1930.
- Reggio, A. W.: Fractures of the Femoral Neck; an End-result Study of Nonoperative Treatment. *Jour. Bone and Joint Surg.*, vol. xii, p. 819, October, 1930.
- Santos, J. V.: Changes in the Head of Femur after Complete Intracapsular Fracture of Neck. *Arch. Surg.*, vol. xxi, p. 470, September, 1930.
- Santos, J. V.: Changes Which the Articular Cartilage of the Hip Joint May Undergo. *Surg., Gynec. and Obst.*, vol. liv, p. 650, April, 1932.
- Smith-Petersen, M. N., Cave, E. F., and Van Gorden, G. W.: Intracapsular Fractures of the Neck of the Femur. *Arch. Surg.*, vol. xxiii, p. 715, November, 1931.
- Speed, Kellogg: Intertrochanteric (Pertrochanteric) Fracture of the Femur. *Am. Jour. of Surg.*, vol. xxxv, p. 123, May, 1921.
- Speed, Kellogg: Locomotion after Impacted Fracture of the Neck of the Femur. *ANNALS OF SURGERY*, vol. lxxix, p. 270, February, 1924.
- Speed, Kellogg: Ununiting Fracture of the Neck of the Femur, Reconstruction Factors Following Union after Fracture. *Trans. Western Surg. Assn.*, 1928-1929.
- Stern, W. G., Reich, R. S., Heyman, C. H. and Papuit, L. E.: The Treatment of Intracapsular Fractures of the Hip-joint. *Surg., Gynec. and Obst.*, vol. liii, p. 250, August, 1931.
- Whitman, Royal: The Abduction Treatment of Fracture of the Neck of the Femur. *ANNALS OF SURGERY*, vol. lxxxi, p. 374, January, 1925.

ANNALS *of* SURGERY

Vol. XCVI

DECEMBER, 1932

No. 6

THE FISSURES OF THE LUNGS*

BY FRANK B. BERRY, M.D. AND EDWARD P. CHILDS, M.D.
OF NEW YORK, N.Y.

FROM THE FIRST SURGICAL DIVISION, BELLEVUE HOSPITAL, NEW YORK

UP TO the present time few, if any, adequate anatomical studies have been made of the interlobar fissures of the lungs. It is our purpose, therefore, to outline briefly a method which has such clinical and exact anatomical advantages as to be decidedly worthy of further pursuit. Several excellent articles have appeared but heretofore all have stopped just short of completion. The authors have written either from the clinico-pathological or Röntgen-ray aspects and in some instances have given excellent anatomical descriptions of the fissures. In only one instance, however—the work of Sampson, Heise, and Brown—has any study been attempted on the cadaver itself with radio-opaque substances to determine the normal and simulated abnormal anatomy by a combination of the ordinary methods of dissection and the use of the X-ray.

History.—Luschka first described the anatomy of the interlobar fissures. "A noteworthy characteristic of the coarse configuration of the lungs is based on their external separation into large interdependent portions, the lobes or wings—lobi pulmonales. These are formed by fissures—*incisuræ interlobulares*—penetrating more or less deeply, sometimes to the vicinity of the root of the lung, with smooth and normally closely approximating surfaces and even, sharpened edges. In each lung, correspondingly, is a large diagonal incision, beginning at the back in the vicinity of the vertebral end of the third rib and extending through almost the entire thickness diagonally, left to the medial end of the sixth rib and right, farther outward from this locality. One may therefore conclude that the apex belongs entirely to the upper lobe and that the anterior circumference is preferably formed by the upper lobe and the posterior by the lower. As a rule only one incision is found in the left lung, while in the right is a second, shorter one, proceeding horizontally at the level of the sternal end of the fifth rib and joining the oblique fissure back of the axillary line. Thus under ordinary conditions we find the right lung divided into three lobes (upper, middle and lower) and the left into two (upper and lower), although as regards the two sides, they correspond in size and shape." Since then later authors have described variations in the arrangement of the fissures.

Laennec was the first to note the involvement of the fissures in disease. He states that encapsulated or circumscribed pleurisies occur in three places most commonly: (1) the fissures; (2) the base of the pleural cavities and on the diaphragm, and (3) in the post-inferior or lateral portion of the chest. He then describes the pathology of interlobar pleurisy at some length. In the latter quarter of the nineteenth century considerable attention was given to their pathology by the French under the leadership of Dieulafoy, who first mentions interlobar collections in 1872, again in his *Manuel de Pathologie Interne* in 1882, and again in his article on Interlobar Pleurisy in 1899. But exudates, cysts, and neoplasms located in the fissures are extremely difficult to diagnose when reliance must be placed solely on often obscure or entirely absent physical signs.

* Read before the New York Surgical Society, November 25, 1931.

Hence, it was not until the advent of the X-ray that any general impetus was given to their study.

Even today, with the aid of the röntgenogram, pathology of the interlobar fissures still remains hidden and difficult of diagnosis and localization. This

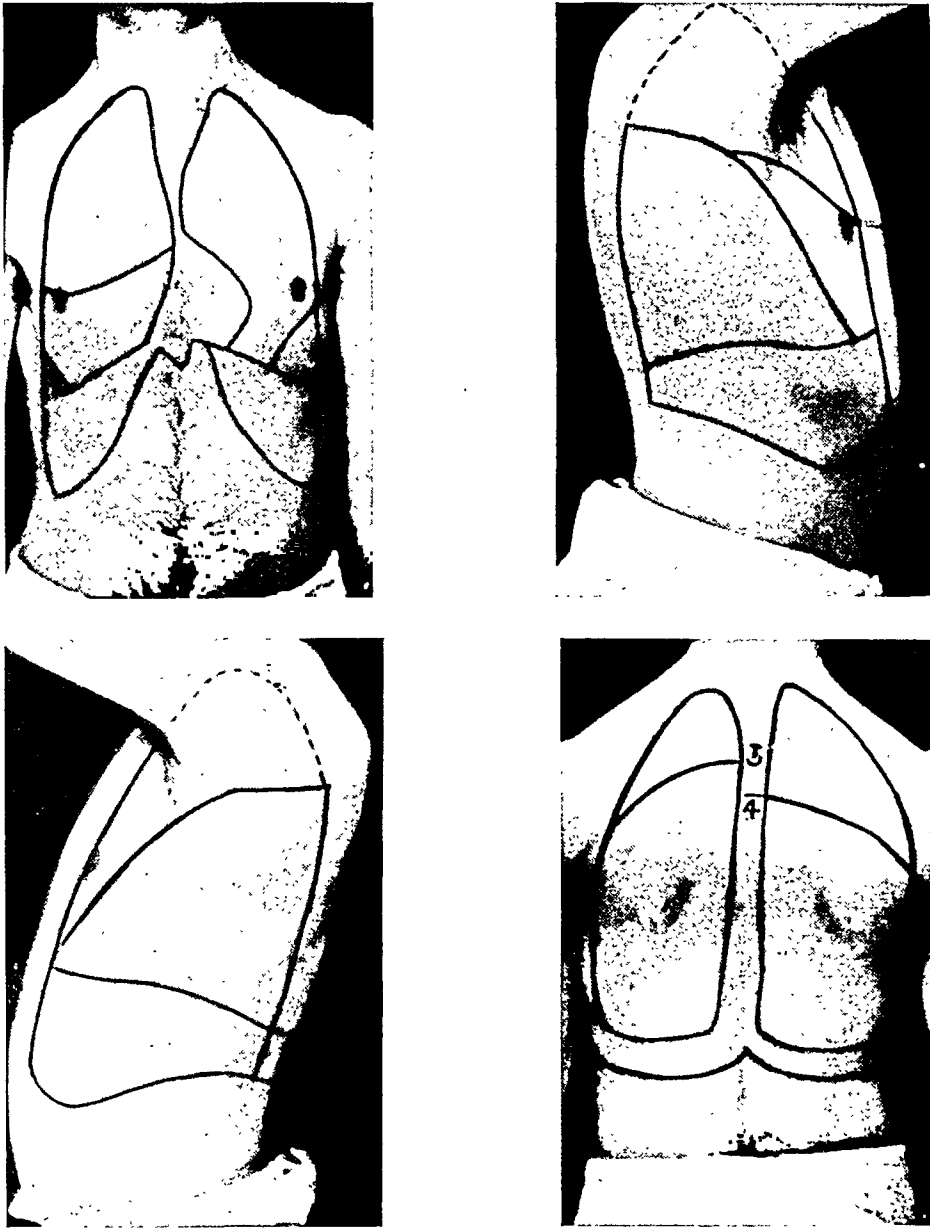


FIG. 1.—Interlobar fissures as marked upon the chest-wall of the normal adult. (From Sampson, Heise and Brown: *Am. Rev. of Tuberculosis*, vol. ii.)

is due, no doubt, in part, to a haziness in the minds of many clinicians and radiologists as to the exact location and extent of the fissures. Also, there is a failure on the part of many to comprehend the possibility of disease here. Impressed by these difficulties, we have sought to find some means of lessening and clarifying them.

THE FISSURES OF THE LUNGS

Normal Anatomy.—For any adequate understanding of the normal anatomy one must, above all else, consider and visualize the interlobar fissures as a series of concavo-convex surfaces meeting about the hilus. In addition, the surfaces of the great fissures are twisted upon themselves so that they form a propeller-like figure, with the upper oval surface facing forward and slightly laterally, and the lower half facing forward and somewhat medially.

The main fissures are given as commencing posteriorly at a varying level between the second and third thoracic spines, or third or fourth thoracic vertebræ. On the left the line begins at the posterior margin of the medial surface of the lung and runs back and up to the posterior surface, where it arches slightly up over the posterior convexity and then runs downward to the level of the sixth costal cartilage, cutting the lung just above the cardiac incisure. It crosses the fourth interspace in the mid-axillary line.

The right fissure starts a little lower, usually at the neck of the fourth rib, and its arch across the posterior surface of the lung is even more gradual than on the left; hence, its descent through the axilla is less steep. In the mid-axillary line it crosses the fifth rib. The diaphragm is reached at a varying point from the mid-axillary line to the sixth costochondral junction. Beginning just anterior to the posterior axillary line in the fourth interspace, the small transverse fissure runs almost horizontally to a varying point beneath the fourth costal cartilage, or even all the way to the anterior border of the lung. It has usually a slight upward convexity but may vary in either direction from the absolute horizontal. The depth and extent of this fissure are notably inconstant, however, so that the middle lobe is frequently merely a divided portion of the upper.

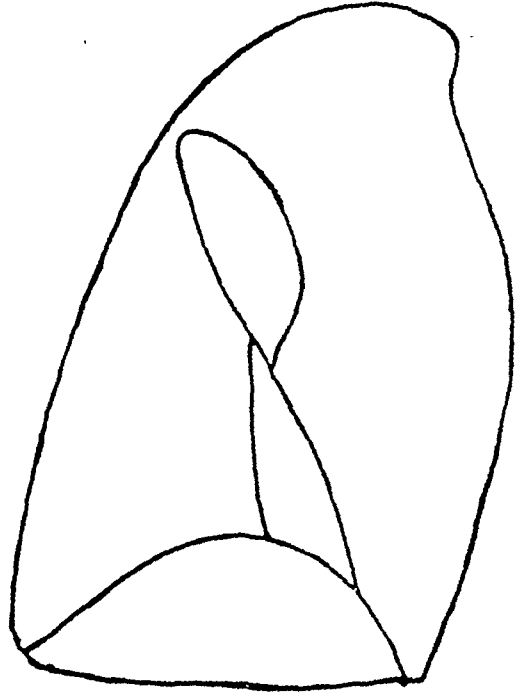


FIG. 2.—Configuration of the main fissures. (After Dietlen.)

Visualization of the deep course of the fissures is difficult and it is hard to realize that they extend to the primary bronchi. Thus the two main fissures divide the lungs into almost equal parts. Although the two main fissures are much more constant than the transverse in their course, still, occasionally, they do not always extend to the mediastinum. Consequently, the upper and lower, or upper, middle, and lower lobes may be more or less interconnected by lung tissue.

On the right the large fissure runs across the phrenic surface of the lung in an oblique medio-dorsal direction. This surface is thus divided into a small antero-medial portion—about one-quarter to one-third of the entire area—belonging to the middle lobe and a large posterior portion belonging to the

lower lobe. At the medial lower border of the lung the fissure extends to the mediastinal surface, ascending almost vertically to the hilum. Thence it ascends steeply posteriorly to the root of the third rib, where it again meets the costal surface of the lung.

The left fissure extends from the lower border of the lungs to the phrenic surface and proceeds similarly to the right. Because the basal pulmonary surface is so interfered with by the heart, only a narrow strip of the upper lobe participates in the phrenic surface. On the mediastinal surface, the course of the fissure approximates that on the right but is somewhat less steep. Both main fissures form a 45-degree angle with the diaphragm.

As already mentioned, these fissures, even normally, may vary appreciably in number and extent, and also, though less constantly, in position. Rochard,



FIG. 3.—Experimental. Lead foil in left fissure.
A-P view.



FIG. 4.—Same as Fig. 3. Lateral view.

in studying empyema in relation to the interlobar fissures, examined twelve cadavers. In these he found that the location of the main right fissure varied posteriorly from the second to seventh ribs and anteriorly from the fifth to seventh interspaces. The transverse fissure began from the fourth to seventh ribs posteriorly and ended from the third space to the sixth rib anteriorly. On the left the start of the fissure varied from outside the costochondral junctions to beneath the sternum itself. In one instance the upper and lower lobes on the right were undivided. To those familiar with surgery of the lungs and pleura these variations are not surprising.

The above describes merely the normal anatomy with the common anomalies and variations. It must be constantly borne in mind that all of this is altered in the presence of existing skeletal deformities or with coexisting pathology of adjacent viscera or spaces such as the heart and pericardium,

THE FISSURES OF THE LUNGS

the liver, the thyroid, the mediastinum and its glands, or subphrenic collections. Also, recent or old pathology in the lungs or pleura themselves may completely change or destroy the normal position, extent, and relation of the fissures.

Experiment.—The great assistance and yet the shortcomings of the X-ray and its interpretation cannot but impress any one who is faced with these problems with any degree of frequency. This failure of exact localization has been demonstrated at operation or autopsy. At best the radiological search, both by fluoroscopy and films, as it should always be, is tedious and exhausting both to patient and examiner. Excellent articles have been written and methods of examinations detailed. But still there seemed room for improvement. First, could not some method be devised whereby, with the



FIG. 5.—Lead foil in right fissure. A-P view.
Note incompleteness of transverse fissure.



FIG. 6.—Same as Fig. 5. Lateral view.

use of radio-opaque substances, the fissures might be completely outlined in the human? Second, with this *a fait accompli*, could we not then, in like manner, simulate focal collections in the fissures *ad lib.* and study them röntgenologically? Thus X-ray films could be made and studied in which the anatomy of the fissures could be definitely and positively seen. This conception is simple enough but its fulfillment is beset with major difficulties of a very practical sort. Fresh subjects must be employed and adequate X-ray studies must be made as expeditiously as possible. We are virtually limited to that small group in which necropsy permission is granted. Furthermore, the pathologist and radiologist must complement each other. This is not easy to attain in our present hospital organization.

Due to the great kindness and sympathetic understanding of one of our pathologists and with the assistance of an expert technician this was made

possible to a limited extent. A portable X-ray outfit was used. With our small equipment only antero-postero and lateral exposures were attainable. The only materials used were a thin lead foil, "brillo," 50 per cent. mercurial ointment, and rubber balloons filled with 50 per cent. sodium iodide solution. The usual median sternal autopsy incision was made. The sternum was left attached at the sterno-clavicular articulations but otherwise freed by cutting through each costal cartilage and the muscular attachments; it was then folded back. Exploration of the pleural cavities and fissures was then made. If adhesions were present, these were carefully loosened as far as possible. The lungs were inflated and the trachea ligated *in situ*. First, the fissures were defined by inserting into each, throughout its entire extent, a thin sheet of lead foil so as just to fill the fissure, if possible. The sternum was replaced,



FIG. 7.—Transverse fissure alone. A-P view.



FIG. 8.—Same as Fig. 7. Lateral view.

the skin loosely sutured, and X-rays made. After this series was completed, similar studies were made with small or large rubber bags filled with 50 per cent. iodide solution, "brillo," or mercurial ointment. These little sacs were placed in the fissures at known points. Only rarely did they slip or change position during the procedure.

From an examination of the films several facts are at once evident. First, even the flat film of the left great fissure demonstrates very well the rotation of the surfaces on each other. Two-thirds of the way down the foil is bent upon itself and a double or oblique denser shadow is cast by its outer portion. Second, from the simple antero-postero film no inkling whatsoever is given that the opaque substances are in the great fissures. The same would apply to a postero-antero film. Only when the respective lateral films are studied is this brought out or suspected, for only then does the position in the sagittal plane become apparent. Third, the transverse fissure,

THE FISSURES OF THE LUNGS

although very variable in extent, gives a characteristic shadow. Shadows here, therefore, are easier of localization than in the great fissures.



FIG. 9.—Balloon of sodium iodide in left fissure near axilla at third and fourth ribs.



FIG. 10.—Same as Fig. 9. Lateral view.

These studies are all too brief and sketchy. It is hoped that they may be elaborated, that oblique and stereoscopic films may be made and also



FIG. 11.—Two balloons with opaque mixture in right main fissure.



FIG. 12.—Same as Fig. 11. Lateral view.

the position of the tube varied. They merely point out a field for future work, once a sufficient organization can be perfected.

ILLUSTRATIVE CASES.—As illustrative of this work I wish to present the following cases, each verified by operation.

CASE I.—B. H., 8742, J. S., male, aged nineteen. *Family History*.—Irrelevant. *Past History*.—Important only in that in 1918 he had a tonsillectomy. This was followed by pneumonia and empyema on the right for which he was operated. He has been well since, until recently, when he began to have pain in his right lower chest in the posterior axillary region. This is aggravated on coughing. He says that for a short time one year ago, he had similar pain there.

Physical Examination.—Physical examination shows a tall, well-developed young man, not appearing very ill. Physical findings are: There is an old scar over the ninth rib in the right posterior axilla with some tenderness about the scar. There is dullness over the base of the right lung posteriorly and diminution of breath sounds here, in the axilla, and over the middle lobe anteriorly. The heart apex is just outside the left nipple line. Physical examination was otherwise negative. Temperature, 99.4°; pulse,



FIG 13—(Case I) A-P view Small exudate present in fissure



FIG 14—(Case I.) Lateral view.

84; white blood-count, 9600; 72 per cent. polymorphonuclears. X-ray showed an interlobar plastic pleurisy between the upper and middle lobes on the right, and an irregular consolidation of the right middle lobe.

Operation.—A diagnosis was made of a sacculated interlobar empyema. The axillary portions of the fourth and fifth ribs on the right were resected for a distance of five centimetres. The pleura was opened along the bed of the fifth rib. The interlobar fissure was found and the lung was adherent to the pleura by delicate adhesions. A round cavity three centimetres in diameter was found in the transverse fissure between the upper and middle lobes. There seemed to be a small bronchial fistula and cavity containing a small amount of pus.

Course.—Following operation a mild pleurisy developed on the same side. Following the subsidence of this the patient made a slow but uneventful recovery, and was discharged, healed, on the thirty-fifth day post-operative and has been well since for the past four months.

CASE II.—B. H. 17349, L. F., female, aged thirty-six. *Family History*.—Irrelevant. *Past History*.—Onset of illness November, 1929, with slight cough. One month later,

THE FISSURES OF THE LUNGS

patient coughed up several mouthfuls of blood; in April, 1930, was confined to bed with what was considered a lobar pneumonia of the right lower lobe. Since then she has continued to cough up about one-half cupful of slightly foul mucopurulent sputum daily, and she has lost about twenty pounds. Also in her history, just before her illness, there is a questionable story of aspiration of a small chicken bone. Signs of dullness and diminished breath sounds at right lower lobe. No definite râles. It was at first considered possibly a case of bronchiectasis following pneumonia. Foreign body in bronchus was also considered.

Laboratory.—Sputum consistently negative for tubercle bacilli; Wassermann, negative; urine, negative; white blood-count, 11,700; polymorphonuclears, 75 per cent.; lymphocytes, 25 per cent.

Bronchoscopic Findings (January 13, 1931).—In the right main bronchus, twenty-nine centimetres from the upper incisors, was a mass nearly filling the lumen of the bronchus, soft and cauliflower-like.



FIG. 15.—(Case III.) Slight thickening of fissures.

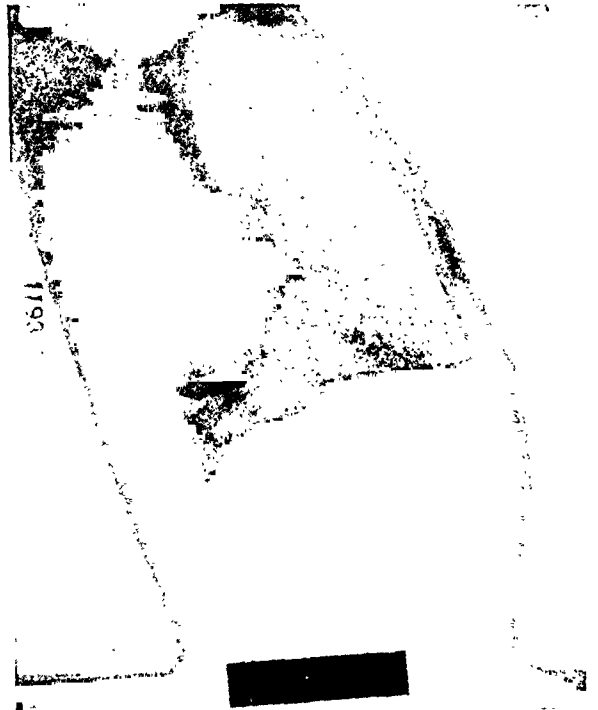


FIG. 16.—(Case III.) Lateral view.

Course.—Patient continued to have hemoptyses. On January 17, 1931, fluoroscopy showed definite elevation of the right leaf of the diaphragm and X-ray showed an atelectasis of the right lower lobe. Patient was operated on March 28, 1931, and a mass arising from the main bronchus of the lower lobe close to its origin and extending into the main fissure at that point was noted. This extended upward and involved the mediastinal glands. The case was quite inoperable, so nothing further was done.

CASE III.—B. H. 16390, M. C., male, aged fifty-eight. Admitted July 3, 1930. Complained of productive cough. *Family History.*—Negative. *Past History.*—Important only in that he had pneumonia twenty years ago. Since then he has had a productive cough. Nine months previous he had a second attack of pneumonia which lasted four weeks and he has a cough and expectoration which have increased since then. For the last four or five weeks he has had dyspnoea on exertion and signs of fatigue. Sputum has been streaked for nine months. Lately he has lost four pounds in weight.

Physical Examination.—Negative except for the right lung. There was dullness from the seventh to tenth vertebral spines on the right and fine and medium râles were heard in this area. X-rays showed a thick interlobar septum and a dense lesion at the root. Reported as a patch of consolidation extending into the right middle lobe.

Bronchoscopy.—"Congestion of the trachea and carina. Considerable congestion and some crusting about the mouth of the right bronchus. On the lateral walls of the right main bronchus about thirty centimetres from the level of the upper teeth and very near the mouth of the middle lobe bronchus there is an area of soft tissue the size of a pea which bleeds freely on contact. Because of this further examination was impossible."

Diagnosis.—The clinical diagnosis lay between abscess or encapsulated empyema. The patient left the hospital but reentered six months later, on February 27, 1931. Cough and expectoration had continued and increased. He had lost twenty pounds in weight. Temperature, 99°; pulse, 80 to 90; white blood-count, 15000.

Physical Examination.—As before. No clubbing of fingers or toes noted. Aspiration of chest in seventh space posterior: six centimetres from skin small amount of pus and



FIG. 17.—(Case III.) Oblique view. Thickening of fissures brought out clearly.

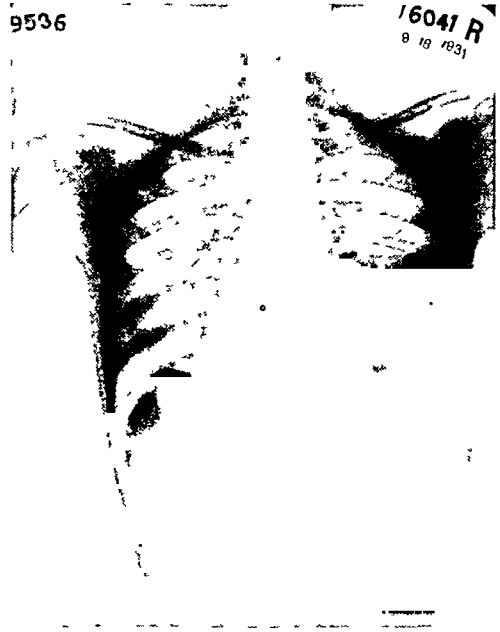


FIG. 18.—(Case IV.) Fluid in fissures

blood obtained. Culture of this showed a hemolytic streptococcus. March 17, 1931, bronchoscopy repeated and biopsy taken. This was reported as epithelioma.

Operation.—Operated in two stages; the first April 15 and the second April 24. Lung very dense and adherent. Pus obtained on aspiration. Lung was opened at the second stage and cavity drained. Malignancy recognized grossly at this time. Patient died May 1, 1931.

Autopsy.—At autopsy the posterior part of the right lower lobe was found broken down and filled with a thick, cheesy, foul-smelling material. The right bronchus was necrotic and gangrenous. One and one-half inches from the bifurcation there was a hard ulcerated area. The middle and lower lobes showed bronchopneumonic consolidation. The fissures themselves were uninvolved. No mediastinal glands.

CASE IV.—The X-rays labelled Case IV are those of a young negress in the tuberculosis ward of Bellevue Hospital. During the course of a moderately extensive bilateral tuberculosis she developed fluid in the left chest with the X-ray films as shown. The lateral view is particularly striking as showing the whole interlobar fissure outlined with a collection of fluid somewhat anteriorly. Later this fluid extended and she developed a large effusion. The exact location was not proved by operation but

THE FISSURES OF THE LUNGS

the shadows were so characteristic that we thought it worth while to include these films in our series.

The above cases illustrate some of the difficulties encountered in the diagnosis of pathology of the interlobar fissures. The physical signs are always obscure and confusing, and are sometimes absent entirely. A relatively small fibrinous or purulent interlobar exudate may give rise to an accompanying greater or smaller serous exudate in the pleural cavity. Three such cases were encountered by us during the past year. Here the physical signs were of no avail whatsoever. Also, the aspirating needle gave what seemed to be misleading results in that only clear blood-tinged serum was obtained, whereas further and deeper exploration revealed frank pus. Almost always in these cases, final reliance must be placed on the aspirating needle, the X-ray, or both. The pitfalls of each should be realized. Proper röntgenological examination means stereoscopic, oblique, and lateral films, and thorough fluoroscopic examination whenever possible. Stoloff describes a very good technic for this. According to him the great fissures are best visualized with the patient in the lordotic position and the tube at the level of the fourth or fifth thoracic vertebra.

Any proper interpretation of the findings by X-ray should presuppose an accurate knowledge of the anatomy of the fissures. Then if the aspirating needle is employed, it must be used intelligently and likewise with an understanding of the anatomy.



FIG. 19.—(Case IV.) Lateral view. Zone of fluid outlined.

SUMMARY AND CONCLUSIONS

A brief résumé of the anatomy of the fissures of the lungs has been presented and a method described for outlining them by anatomical and röntgenological studies.

Also, several cases of interlobar disease have been presented in detail. Case I is a typical instance of interlobar empyema in the small transverse fissure. In Case II the tumor projected into the main fissure at the hilus although this was not diagnosed from study of the X-ray films. In Case III the interlobar fissure is shown and the diagnosis was made of interlobar empyema. Autopsy, however, revealed that the lesion was entirely intrapulmonary except for a slight thickening of the interlobar septum. Case IV seems to represent a very characteristic shadow of a sacculated collection in

the main fissure of the left lung. This illustrates excellently, even where the shadows are perfectly typical, the difficulties involved in the interpretation of X-ray films as to the relation of the lesions shown to the fissures.

Diagnosis of the interlobar disease is at best difficult. A thorough knowledge of the anatomy of the fissures must be combined with their visualization by X-ray and careful röntgenological interpretation.

The method of study outlined above is suggested as an aid to a better understanding of this problem.

BIBLIOGRAPHY

- Chauffour, H.: *Prat. Med. franc.*, vol. x, p. 509, November, 1929.
- Dieulafoy, G.: *Du diagnostic et traitement des épanchements aigus et chronique de la plevre par aspiration.* Paris, 1872.
- Ibid*: *Manuel de Pathologie Interne.* Paris, 1882, fifteenth ed., 1908.
- Ibid*: *La Pleuresie Interlobaire.* Clin. Med. de l'Hôtel Dieu., 1899.
- Dietlen, Hans: *Interlobar Pleuritis.* (Ueber interlobäre pleuritis.) *Ergeb. d. inn. Med. u. Kinderhlt.*, vol. xii, pp. 196-217, 1913.
- Fleischner, Felix: *Lobar and Interlobar Pulmonary Processes.* Lobare und interlobäre Lungenprozesse.) *Fortschr. a. d. Geb. d. Röntgenstr.*, vol. xxx, pp. 181-185; pp. 441-473, 1922-1923.
- Laennec: *Traite de l'auscult. Med.*, vol. ii, second ed., 1826.
- Luschka: *Anat. des Menschen.*
- Musser, J. H.: *J. A. M. A.*, vol. xlviii, p. 24, 1907.
- Rochard: *Gaz. des Hop.*, vol. xxxi, pp. 65, 211, 1892.
- Sampson, H. L., Heise, F. H., Brown, L.: *Am. Rev. Tuberc.*, vol. ii, p. 664, 1918, 1919.
- Stoloff, E. G.: *Am. J. Dis. Child.*, vol. xxxviii, p. 75, (1), 1929.
- Stone, A. K.: *Tr. Am. Clin. Assoc.*, vol. xxvii, p. 181, 1911.

LINGUAL THYROID

BY RODERICK V. GRACE, M.D., AND CARNES WEEKS, M.D.

OF NEW YORK, N. Y.

FROM THE FIRST SURGICAL DIVISION OF BELLEVUE HOSPITAL

THE presence of thyroid tissue at the base of the tongue in the region of the foramen cæcum is an uncommon condition. There have been approximately 130 such cases reported in the literature. Dore,¹ in 1922, in a Bordeaux thesis collected 102 case reports and gave a careful analysis of eighty-one of them. Bisi,² in 1930, has brought the literature in this subject up to date.

Apparently, the author to first cite a clinical case of lingual thyroid was Hickman,³ in 1869, who reported the death of a sixteen-hour-old infant from asphyxiation caused by a goitre at the base of the tongue. Cattell and Hoover,⁴ in 1929, report but two cases of lingual thyroid in over 7,600 thyroids operated on at The Lahey Clinic. As the symptoms, pathology and treatment of this condition are usually so much the same in the cases reported it seems unnecessary to collect and analyze the 130-odd case reports. The object of this paper, then, is to add another example of a lingual thyroid successfully operated upon and to discuss briefly the embryology of the thyroid gland and its effect on various possible positions of aberrant thyroid tissue.

CASE.—The patient, M. L., a young American woman of twenty-five years, a bank-teller, was admitted to the First Surgical Division of Bellevue Hospital with a chief complaint of "lump in the throat" of five years' duration. Five years previously she had consulted her local physician who had told her that there was a tumor at the base of the tongue. Other than a feeling of a foreign body at the base of the tongue, there were no symptoms until three months before admission, when the "lump" began to cause trouble. She had occasional dysphonia and was bothered by a bad taste in her mouth in the morning and the presence of a brown sticky secretion together with a tickling sensation of the posterior pharynx. There was no history of hæmorrhage, dyspnoea, dysphagia, or pain. She said that she had lost fourteen pounds in weight in two months.

In the oropharynx arising from the centre of the base of the tongue in the region of the foramen cæcum and extending down and back there was a globular, sessile mass one and one-half inches by one inch. (Fig. 1.) The surface was smooth and covered with mucous membrane similar to that in the buccal region. Over its surface coursed two large veins superficially from the base of the tongue. This mass was firm. Its posterior and inferior aspect lay upon a short but otherwise normal epiglottis. The larynx was normal.

On palpating for the cervical thyroid it seemed that the isthmus was absent, but it was felt that the lateral lobes were present. There was no clinical evidence of myxœdema. The basal metabolism was minus 3 per cent. The rest of the physical examination was negative. The pulse rate was normal. The tumor was tapped and a small amount of straw-colored fluid was aspirated.

Operation.—August 29, 1930, under avertin anaesthesia, eighty milligrams per kilo-

metre, and five cubic centimetres 1 per cent. novocaine placed directly into the base of the tongue by the suprahyoid route, the tumor was attacked. Several strong silk sutures were passed through the tongue and the latter drawn forcibly forward. A transverse incision was then made in the mucous membrane at the junction of the tongue with the mass. The tumor was then shelled out by blunt and sharp dissection after finding a clear plane of cleavage. There seemed to be a rather definite submucous pedicle running to the region of the foramen cæcum.



FIG 1—Showing the position of the lingual thyroid at the base of the tongue

The pedicle was cut between ligatures. The mucous membrane was then brought together with three No 1 chromic sutures.

As the patient was about to be transferred to the stretcher, she stopped breathing. By artificial respiration and inhalations of carbon dioxide and oxygen, normal respiration finally was established. We believe that this accident was due to a rather large dose of avertin.

The patient made an uneventful post-operative recovery and at the present time, four months post-operative, is completely well. There is no sign of local recurrence of tumor. The basal metabolism is minus 26 per cent. but there are no clinical signs of myxœdema.

Pathology.—The mass removed at operation weighs 85 grams, and measures 33

LINGUAL THYROID

centimetres by 2.3 centimetres. On section there are several areas containing dark homogeneous colloid material. The rest of the tissue has the appearance of normal-looking thyroid. (Fig. 2.)



FIG. 2.—Lingual thyroid tumor after enucleation.

On microscopical examination there are areas of adenomatous tissue in between large numbers of dilated and irregular shaped follicles whose epithelium is high and which contain dark-staining colloid. (Fig. 3.) Some of the follicles contain a large

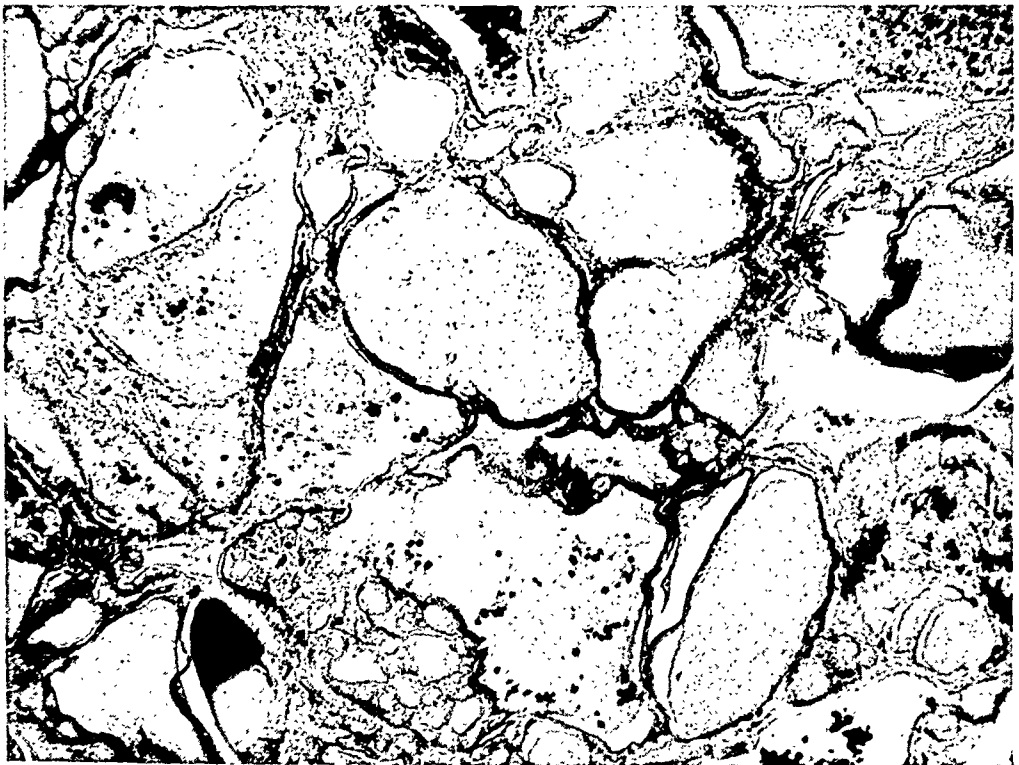


FIG. 3.—Section showing characteristic thyroid tissue with dilated follicles. (x75.)

number of cells which are distended with brown pigment. There is a marked fibrosis and a slight amount of round-cell infiltration.

Pathological diagnosis.—Mixed colloid and adenomatous thyroid.

Embryology.—The whole of the functioning adult thyroid comes from a median anlage in the floor of the pharynx. This anlage occurs early. In 2.5 millimetres embryo, it develops a projection which soon takes the form of a sac or pouch. As the latter grows it moves backward and downward, retaining its connection with the floor of the pharynx by a narrow stalk, the thyroglossal duct. The latter has an orifice which opens into the pharynx as the foramen cæcum. As the pouch and its duct migrate downward into the neck it becomes bilobed and the thyroglossal duct has a double lumen. The stalk or thyroglossal duct then atrophies, and the bilobed pouch becomes differentiated into the isthmus and the lateral lobes of the thyroid gland. The hyoid bone develops later and the thyroglossal duct may pass in front of, through, or behind the bone.

It was thought at one time that the ultimobranchial bodies were the lateral thyroid anlagen. They arise from the ventral part of the fifth pharyngeal pouch and are described in some mammals as actually contributing active thyroid tissue to the lateral lobes. They have been described as fusing with the lateral lobes in the human, but whether they contribute actively functioning thyroid tissue is in doubt. If they do it would be hard to explain those cases in which the median thyroid anlage had been arrested in its descent, forming, say, a sublingual mass of thyroid tissue, and when the latter was removed surgically, myxœdema occurred. This condition, an extremely important one to know about, is not at all uncommon. If active thyroid tissue was formed by these lateral anlagen, the ultimobranchial bodies, true ectopia thyroidis would be hard to account for as they should theoretically supply enough thyroid to prevent the individual from developing myxœdema.

The few embryological facts outlined above explain satisfactorily the common variations of position of the thyroid found in man. Thyroid tissue may then be found at any point along the course in the descent of its median anlage from its original position at the foramen cæcum to its ultimate site on the upper tracheal rings. Thus we may find it at the foramen cæcum as a lingual thyroid in the substance of the tongue, as an intralingual thyroid below the hyoid bone, as was described by Verneuil⁵ in 1853 (he being the first to recognize and report the presence of accessory thyroid tissue) as thyroid lying in the lower part of the thyroglossal duct (pyramidal lobe), and finally normal gland.

It is possible, of course, to find accessory thyroid tissue in other positions than in close relation to the normal situation of the gland or the course of its descent. It would be due to a small piece of the original remnant that had wandered off to any remote situation.

Leech, Smith and Clute,⁶ and Cattell and Hoover⁴ have described aberrant thyroid tissue in lateral positions with no demonstrable connection with the main body of the gland. All these cases, however, showed a low-grade malignancy. They believe that these were derived from the ultimobranchial bodies.

The thyroid gland may be absent, the isthmus may be lacking or only one lobe may be present.

We believe that the most important clinical fact to be determined from the embryological development of the gland is whether in these cases of lingual thyroid the whole functioning gland is represented in the lingual element, true ectopia thyroidis, or that the normal gland also is present in its usual pre-tracheal position. The reason for this is obvious.

Dore,¹ in analyzing eighty-one cases of lingual thyroid, reports myxœdema developing in seven following surgical removal of the lingual tumor, a ratio of about one in every eleven cases. More recently, Hartley⁷ reports a case of true ectopia thyroidis in which he removed a tumor the size of a cherry from above the hyoid bone, the patient developing marked symptoms and signs of hypothyroidism in eight weeks. Lahey,⁸ Cattell and Hoover,⁴ Torrigiani,⁹ and Bisi² have also reported such cases. Torrigiani merely took a biopsy from the lingual tumor because he could not feel the normal thyroid. This we believe to be an extremely important point. Hartley emphasizes the fact that if the isthmus of the gland cannot be felt one should be suspicious that the condition is one of an ectopic gland.

The lingual thyroid is much more common in women than in men. The ratio is about eight to one. The average age of the patients is twenty-three years. The onset of the symptoms very frequently occurs at the age of puberty, although some adults have given a history of such tumor being present since birth. Several cases of lingual thyroid in the new-born have been reported.

The symptoms are those of any benign tumor at the base of the tongue, the feeling of a foreign body at the base of the tongue, dysphonia, dysphagia, dyspnœa and actual asphyxia, as in Hickman's case. Hæmorrhage from the large vessels which may course across the tumor is not uncommon and occurred in eight of Dore's eighty-one cases. On inspection the mass is liable to be missed, unless the tongue is pulled far forward. The ordinary method of depression tends to push the mass out of view. The tumor is frequently first seen by the laryngologist; this occurred in our case. The tumor, which may be deeply imbedded in the root of the tongue, usually projects from the dorsum. It is single, situated in the region of the foramen cæcum, and usually has a broad base. Harvey¹⁰ has recently described one with a pedicle, a rare condition. The tumor is red in color, slightly lobulated and covered with normal mucous membrane which may contain several large veins arranged in typical manner. The various sizes of the cases observed have ranged from that of a pea to that of an orange. In the latter case the entire oropharynx was filled by the mass.

An extremely careful examination of the neck should be made to ascertain the presence or absence of the normal thyroid gland. If the normal gland cannot be felt, one should hesitate to remove the lingual thyroid unless the symptoms arising from it make its extirpation imperative. Myxœdema can, of course, be fairly well controlled with thyroid feeding but occasionally

this distressing condition fails to be relieved by medication. Pre-operative and post-operative basal metabolism rates should of course be done. The surgical approach to a tumor of this kind depends on its exact situation. In the authors' case the oral route was obviously the simplest. For those tumors lying deep in the tongue or just above the hyoid bone a suprahyoid incision would be most satisfactory.

In conclusion, we wish to draw attention again to the change in the basal metabolic rate of this patient from minus 3 per cent. pre-operatively to minus 26 per cent. post-operatively. While other clinical manifestations of myxœdema are at present lacking in this patient, she will be started on a course of thyroid feeding. The amount of the feeding and its duration will be controlled by her follow-up examinations and future metabolism tests.

BIBLIOGRAPHY

- ¹ Dore, F. R.: Bordeaux Thesis, 1922.
- ² Bisi, H.: *Rev. de espec.*, vol. v, pp. 895-919, 1930.
- ³ Hickman: *Path. Trans.*, vol. xx, p. 160, 1869.
- ⁴ Cattell, R. B., and Hoover, W. B.: *Surg. Clin. North America*, vol. ix, pp. 1355-1362, 1929.
- ⁵ Verneuil, F.: *Arch. gén. de méd.* vol. i, p. 185, 1853.
- ⁶ Leech, Smith, and Clute: *Amer. Jour. Path.*, vol. iv, p. 481, 1928.
- ⁷ Hartley, J. N. J.: *Surg., Gynec., and Obst.*, vol. xxxv, pp. 543-552, 1922.
- ⁸ Lahey, F. H.: *Surg., Gynec., and Obst.*, vol. xxxvi, pp. 395-397, 1923.
- ⁹ Torrigiani, C. A.: *Scritti Biol.*, vol. ii, pp. 167-177, 1927.
- ¹⁰ Harvey, F.: *Brit. Jour. Surg.*, vol. xiii, pp. 746-748, 1925-1926.

SALIVARY CALCULI *

BY ROBERT H. IVY, M.D., D.D.S., AND LAWRENCE CURTIS, M.D., D.D.S.
OF PHILADELPHIA, PA.

FROM THE EVANS INSTITUTE AND THE GRADUATE HOSPITAL OF THE UNIVERSITY OF PENNSYLVANIA

DURING the past eleven years ninety-six patients have consulted us with symptoms indicating obstruction of ducts of salivary glands. In seventy-three calculi were demonstrated clinically or radiographically. There is a very extensive literature on this subject, many observers reporting isolated cases, while a few writers present analyses of large series. It is obviously impossible to review all of the literature here. Recent personal series are reported by Harrison,¹ in 1926 (twenty-seven cases), and by New and Harper,³ in 1931 (seventy cases). Up to the time of Harrison's paper, he states that search of all available literature from 1825 resulted in finding only 375 cases. We feel that our experience is sufficient justification for presentation of a paper on a condition which, while much more common than the figures quoted would indicate, yet is frequently overlooked.

Etiology.—It is not our purpose to dwell upon the theories that have been advanced to account for the formation of salivary calculi. Some writers claim that inflammation in the gland itself is a common cause of stone formation. Against this is the frequency of inflammation of the parotid gland and the infrequency of stone formation in this region. The most significant work on the etiology and pathology of salivary calculus has been done by Söderlund⁸ and Naeslund, of Sweden. In 1919, Söderlund first definitely associated salivary calculus formation with actinomycotic infection. He⁹ has since reported a series of forty-one cases in which examination of the calculi showed the presence of actinomycetes in all. He and Naeslund believe the cause in some cases to be the saprophytic actinomycetes inhabiting the mouth, while in others that the organisms are introduced into the salivary ducts directly from outside the body. These writers hold that colonies of the organisms in the ducts cause a decomposition in the protein of the saliva, bringing about a precipitation of calcium salts by reason of a change in the hydrogen-ion concentration. The lime salts are deposited around the colonies of the organisms. Naeslund states that other bacteria can also cause precipitation of lime salts from saliva in the same way, but that the physical make-up of these other bacterial colonies is not so favorable for the deposit in and around them of the lime salts as it is in the case of the mycelium-forming actinomycetes. Naeslund² examined fifty cases of salivary calculus and found an actinomycotic stroma in all. He was also able experimentally to produce calculi from cultures of actinomycetes obtained from natural salivary calculi. He found in salivary calculi saprophytic forms of actinomycetes as well as the Wolff-Israel

* Read before the Philadelphia Academy of Surgery, March 7, 1932.

pathogenical strain. This would explain why salivary calculus formation can be so frequently present unaccompanied by a pathological actinomycotic process in the tissues. This conception of the cause of salivary calculus has so recently been brought to our attention that we have not had an opportunity to investigate it in our own cases, but we shall do so as new cases present themselves. In most salivary stones a combination of calcium phosphate and calcium carbonate predominates.^{4, 6, 10} Many writers stress the presence of foreign bodies in the salivary ducts as the starting point of calculus formation. The actual demonstration of a macroscopical foreign body in the calculus is rare. In one of our cases of abscess of the parotid gland, we found a husk of wheat impacted in the duct, but no calculus had formed around it. There was an actinomycotic infection in this case.



FIG. 1.—Swelling of left submaxillary salivary gland, due to obstruction of duct by large calculus shown in Fig 5. Note absence of trismus.

Of the seventy-three cases of our series in which calculi were present, sixty-six were connected with the submaxillary gland or duct, and seven with the parotid, a proportion of almost 10 to 1.

Of the submaxillary cases forty-seven occurred in males and nineteen in females, a proportion of about $2\frac{1}{2}$ to 1. As to the side involved, there were thirty-seven on the left side, twenty-three on the right side, two were bilateral, and in four the side was not recorded. The X-ray revealed the stones in forty-four cases of sixty-six, while they were demonstrated clinically in twenty-two.

Of forty-three cases in which the age was noted, the youngest was sixteen and the oldest seventy-nine years. A larger number occurred in the third decade than in any other.

Of the seven parotid cases, five occurred in males and two in females. The

SALIVARY CALCULI

right side was involved in three, the left in three and in one the side was not recorded. The X-ray showed the stones in four cases while in three cases they were demonstrated clinically. Single stones were present in all of the parotid cases.

SYMPTOMS AND DIAGNOSIS.—*Submaxillary Gland and Duct.*—In typical inflammatory obstruction of the duct of Wharton by a calculus, no difficulty should be encountered in diagnosis. There will be an acute or a subacute swelling in the submaxillary region, well circumscribed, and tender to pressure, and not adherent to the overlying skin (Fig. 1). Fifty-nine of sixty-six



FIG. 2.—Illustrates how a calculus in anterior portion of submaxillary duct may be masked by shadow of mandible in extra-oral X-ray film. (Radiograph by Dr. L. M. Ennis.)

patients presented a submaxillary swelling. Pain may be severe, especially on attempts at swallowing. This painful enlargement is particularly noticeable at meal-times (salivary colic), an association noted in thirty-six of our patients. There is no limitation in opening the mouth. The duration of symptoms in our cases varied from a few days up to seventeen years. Nineteen were seen during the first attack and in thirty-seven multiple attacks were recorded, with intervals of comparative comfort between. During an acute attack, a tender, oedematous swelling will generally be found in the floor of the mouth along the course of the duct, on the same side as the submaxillary enlargement. The outlet of the duct at the side of the frenum of the tongue

may be reddened, and pus may be expressed from it. This symptom was recorded in forty-four of sixty-six cases. A tender hard nodule—the calculus—may be felt somewhere along the course of the duct in the floor of the mouth, by combined intra-oral and extra-oral palpation. Fever and leucocytosis are usually present during the acute attacks.

The diagnosis is easy when the stone is seen to be partly extruded from the orifice of the duct. It is in the milder or subacute recurrent cases that there is more excuse for overlooking the true condition. Here, the only indication may be more or less mild recurrent attacks of circumscribed tender swelling in the submaxillary region, with no particular complaint in the floor of the mouth. The likelihood of a stone should, however, always be thought of under these circumstances, and careful inspection will frequently show reddening or swelling about the orifice of the suspected duct, or pressure may



FIG. 3.

FIG. 4.

FIG. 3.—Same case as Fig. 2. Calculus clearly shown in intra-oral occlusal film. (Dr. L. M. Ennis.)
 FIG. 4.—Intra oral occlusal film fails to show calculus in posterior part of submaxillary duct. (Dr. L. M. Ennis.)

force out a little pus. On minute palpation a point of tenderness or a hard nodule may be felt in the floor of the mouth. X-ray examination is valuable in confirming the diagnosis. Many submaxillary stones are overlooked by failure to make a proper X-ray examination. The usual small dental films placed against the lingual sides of the teeth and gums will, of course, not cover the submaxillary duct region. The ordinary external film of the lower jaw region will frequently fail to show a small stone situated in the anterior part of the duct as the stone shadow may be hidden by that of the mandible. (Fig. 2.) Where a calculus is suspected in the anterior two-thirds of Wharton's duct, a No. 2 film ($2\frac{1}{2}$ by $3\frac{3}{4}$ inches) is placed in the occlusal plane between the upper and lower teeth as far back in the mouth as possible with the sensitive side down, and the patient instructed to bite on it. The rays are directed from beneath the chin. This will give a clear shadow of any opaque substance

SALIVARY CALCULI

in the floor of the mouth. (Fig. 3.) If the stone is farther back, near the beginning of the duct, a lateral extra-oral film may be necessary to show it. (Figs. 4 and 5.) Multiple calculi may be shown by the X-ray, when unsuspected clinically, a fact which has an important bearing on treatment, so that even though a positive diagnosis has been made clinically, X-ray examination should not be neglected, for this reason. (Figs. 6 and 7.)

Differential Diagnosis.—Obstructive enlargement of the submaxillary salivary gland is commonly mistaken for a lymphadenitis or a cellulitis due to infection from teeth or tonsils. In the majority of cases that have come to



FIG. 5.—Same case as Fig. 4. Extra-oral film showing large calculus in posterior part of duct. This calculus was almost spherical, about two centimetres in diameter, weighed three grams, and was removed by an incision in the mouth. (Dr. L. M. Ennis.)

our notice, the patients have been told that the trouble was probably due to infection from the teeth and many have had one or more teeth extracted without relief. Careful note of history of symptoms, and examination as outlined above, with *absence of trismus*, will usually exclude a cellulitis of dental origin.

The presence of a subacute swelling in the submaxillary region, associated with soreness in the floor of the mouth, especially in a person of middle age or beyond, may lead one to entertain a suspicion of malignancy. In a carcinomatous metastasis to submaxillary and cervical lymph-nodes, the mass in the neck is usually fixed and markedly indurated, frequently bound both to

the skin and to the bone. The submaxillary gland when enlarged from stone in the duct is usually more deeply seated, is not fixed to skin or bone, and has an elastic feeling. The X-ray examination usually clears up the question.

Ranula is confused with obstruction of the submaxillary duct by writers from time to time, and considerable confusion seems to exist regarding this condition. Statements are constantly appearing in the medical and dental literature^{5, 7} that ranula, a cystic swelling of the floor of the mouth, may be due to a calculus lodged in the duct of the submaxillary gland. Submaxillary duct obstruction cases should never be classified with ranula, the symptoms being entirely different. Ranula is a soft, painless, transparent swelling beneath the mucous membrane of the floor of the mouth, containing clear ropy fluid. The exact cause is unknown, but it may be due to inflammatory closure



FIG. 6.



FIG. 7.

FIG. 6.—Three calculi in one submaxillary duct. (Dr. L. M. Ennis.)

FIG. 7.—Bilateral submaxillary duct calculi. One was two centimetres and the other three centimetres in length. (Dr. G. E. Pfahler.)

of one of the ducts of the sublingual gland or of one of the smaller mucous glands in this region. It is never associated with a calculus, nor with a swelling in the submaxillary region, as would be the case if the submaxillary duct were involved. Furthermore, in ranula the submaxillary duct can usually be identified and isolated completely from the cystic swelling.

Parotid Gland and Duct.—Here, the symptoms differ only in location from those of submaxillary duct obstruction. All of our seven cases were manifested by a painful external swelling over the region of the parotid gland. Three gave a history of increased pain and swelling in relation to eating. In six pus could be expressed from the orifice of Stenson's duct. Three patients were seen during the first attack while four had had several attacks,

in two cases, over a period of two years. Parotid calculi are much more difficult to demonstrate radiographically than those in the submaxillary region. The examination is best made by the anteroposterior position, the operator endeavoring to throw the parotid gland region on the X-ray film external to the shadow of the ascending ramus of the lower jaw. Sometimes a calculus can be demonstrated by placing a small dental film in the vestibule of the mouth over the duct with the sensitive side toward the mucous membrane of the cheek. (Fig. 8.) Of seven parotid cases, the X-ray examination was positive in four. In one case the calculus was encysted in the gland substance.

TREATMENT.—Submaxillary Calculus.—The treatment of obstructive enlargement of the submaxillary gland from calculus in Wharton's duct is primarily removal of the calculus. If the stone is in the anterior two-thirds of the duct, this can be accomplished by an incision through the mucous membrane of the floor of the mouth under local anæsthesia. The cases vary greatly in difficulty. As a general thing the larger the calculus the easier its removal. The most difficult cases are those of small calculi which are movable in the duct. Anæsthesia is best obtained by injecting the lingual nerve, as in the mandibular injection for the extraction of teeth. The mucous membrane is incised in the direction of the duct. A large calculus can then be readily felt with the finger, the duct incised, and the stone liberated. In case of a small stone, with little or no surrounding inflammatory reaction, the tissue can be grasped with forceps behind the stone, or a suture can be passed around the duct to prevent the stone from slipping back while the incision is being made. In non-suppurative cases, the mucous membrane incision can be sutured without drainage. If much inflammatory reaction or suppuration be present, a small wick of gauze or strip of rubber dam should be left in the incision. There is frequently considerable reaction following the trauma of this operation, lasting for a few days, which may be partially controlled by hot mouth washes and the application of ice externally. Pain may call for a sedative, although in most cases relief of pain and discomfort is almost immediate after the operation.

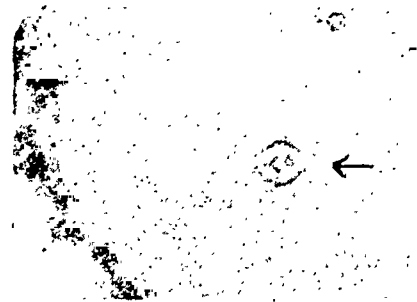


FIG. 8.—Calculus in parotid duct shown by small dental film placed against mucous membrane of cheek. (Dr. L. M. Ennis.)

If the calculus lies near the point at which Wharton's duct is given off from the gland, its removal by external incision is indicated. In cases of long standing, the gland undergoes degenerative changes from chronic inflammation, and even removal of the obstruction does not effect a return to normal. Here, it is advisable to remove the gland as well as the stone. In this operation, the usual skin incision runs about an inch below and parallel with the lower border of the mandible from just behind the symphysis to the angle. The platysma is divided along the same line and turned up as a separate layer. In dissecting out the gland the facial artery and vein are

divided and tied. In completing the operation the platysma and skin are sutured in separate layers. A small rubber dam drain is usually inserted for twenty-four or forty-eight hours. Very frequently one of the cervical branches of the facial nerve is cut during the operation, causing a characteristic inability to depress the corner of the mouth, due to paralysis of the triangularis menti muscle. Spontaneous recovery or improvement may occur with time. This accident is difficult to avoid, but there is less chance of its occurrence if the incision be made well below the border of the jaw.

In our series of fifty-seven cases which came to operation, fifty-one were removed by incision within the mouth, and six by external incision.

Parotid Calculi.—These are usually removed by an incision into the duct from the mouth. Of six cases in our series, the duct was opened from the mouth in five, while in one case of stone encysted in the gland, this was removed through a skin incision. Since there was no obstruction of the duct in this case, no permanent salivary fistula resulted from the operation.

SUMMARY AND COMPARISON WITH OTHER SERIES

	<i>Submaxillary</i>	<i>Parotid</i>	<i>Sublingual</i>	<i>Total</i>
Ivy and Curtis	66	7	—	73
Harrison	15	10	2	27
New and Harper	66	3	2	71

Incidence According to Sex

	<i>Males</i>	<i>Females</i>	<i>Total</i>
Ivy and Curtis	52	21	73
Harrison	19	8	27
New and Harper	45	25	70

Side Affected

	<i>Right</i>	<i>Left</i>	<i>Bilateral</i>	<i>Not Noted</i>
Ivy and Curtis	26	40	2	5
Harrison	16	11		
New and Harper	Right almost twice as often as left.			Bilateral 2.

Operation

	<i>Removal through Mouth</i>		<i>Removal by External Incision</i>	
	<i>Submaxillary</i>	<i>Parotid</i>	<i>Submaxillary</i>	<i>Parotid</i>
Ivy and Curtis	51	5	6	1
New and Harper	43	Not Stated	27	Not Stated

BIBLIOGRAPHY

- ✓¹ Harrison, G. R.: Surg., Gynec., and Obst., vol. xliii, p. 431, 1926.
- ² Naeslund, C.: Acta path. et microbiol. scand., vol. vi, p. 78, 1929.
- ✓ New, G. B., and Harper, F. R.: Surg., Gynec., and Obst., vol. liii, p. 456, 1931.
- ✓ Prinz, H.: Dent. Cosmos, vol. lxiii, pp. 231, 369, 503, 619, 1921.
- ⁵ Shelmire, B.: So. Med. Jour., vol. xxiii, p. 979, 1930.
- ✓⁶ Shuh, C.: Ueber Speichelsteine. Inaug. Dissert., Heidelberg, 1913.
- ⁷ Singleton, D. L.: Dent. Cosmos, vol. lxx, p. 985, 1928.
- ✓⁸ Söderlund, G.: Acta chir. scand., vol. liii, p. 189, 1920.
- ✓⁹ Söderlund, G.: Acta chir. scand. (Supp. No. 9), vol. lxiii, pp. 1-237, 1927.
- ✓¹⁰ Wakeley, C. P. G.: Lancet, vol. i, p. 708, 1929.

ACUTE EMPYÆMA OF THORAX*

THE IMMEDIATE AND LATE RESULTS IN A HUNDRED CONSECUTIVE CASES

BY CALVIN B. RENTSCHLER, M.D.

OF READING, PA.

FROM THE SURGICAL SERVICE OF THE READING HOSPITAL

THIS paper is based on an analysis of the immediate and late results of 100 consecutive cases of acute empyæma surgically treated at the Reading Hospital from 1920 to 1930.

The data covering the end-results was obtained by a questionnaire sent to the patient and information received from the patient, a member of the immediate family, or from the family physician. The questionnaire was sent out three months after the last patient was discharged from the hospital.

Ætiology.—In the series of cases under consideration, 75 per cent. occurred as a complication of pneumonia. In 10 per cent. pleurisy was considered the cause. In 11 per cent. the origin of the trouble was not clear. The patients in most instances in the latter class complained of malaise, vomiting, fever, and some difficulty in respiration. Grippe or influenza was the preceding illness in four patients. Again, in one case, a cold, and in another, a discharging ear was considered to be the ætiological factor. Table I presents the ætological organism and the mortality in each group.

TABLE I

Culture	Number of Cases	Deaths	Mortality Per Cent.
Not stated.....	32	1	3.12
Pneumococcus.....	26	0	0.
Streptococcus.....	25	5	20.0
Mixed.....	11	3	27.27
Staphylococcus	6	1	16.66

The age distribution is best demonstrated by Table II which shows the age and the mortality.

TABLE II

Age	Number of Cases	Deaths	Mortality Per Cent.
1 to 2 years	21	3	14.28
3 to 12 years.....	46	2	4.34
Over 12 years.....	33	5	15.15

The youngest patient was eight months and the oldest was seventy-three years. Both of these recovered.

Sex Distribution.—There were fifty-six males and forty-four females.

Side Involved.—In fifty-five instances the right pleural cavity was involved and in forty-five the left side was affected. In one case the condition was bilateral. It is probably not of much significance that in the female the left side was as frequently involved as the right, whereas in the male the

* Read before the meeting of the Berks County Medical Society, May, 1932.

right side was the seat of trouble in thirty-four instances and the left in twenty-one instances.

Treatment.—The war treatment of empyæma, although it was handling the influenza type of empyæma, an entirely different empyæma from our common everyday variety of empyæma, has nevertheless brought out two important lessons. *First*, the extreme value of not opening the chest too hastily, and *second*, the employment of the most conservative operation in the very sick patient.

In an old empyæma where drainage is paramount, any procedure short of rib-resection is futile.

In all cases of the present series aspiration was done first. This was done in most cases only as a diagnostic procedure. The type of surgical treatment employed can best be seen by the chart in Table III. It will be noted that sixty-nine patients had partial resection of one rib with the insertion of several rubber tubes. Twenty-two patients had intercostal drainage instituted by intercostal incision or by trochar. The drain in these cases consisted usually of a rubber tube, or more infrequently, a metal cannula with the drain left open. In only a few cases was the drain used as a closed method of treatment. Six patients had intercostal drainage followed later by a partial rib-resection. One patient had a partial rib-resection with counter-drainage by a lower incision. In two patients aspiration was the only treatment employed.

The patient with bilateral empyæma had a thoracotomy on the right side, which was also the side first and most extensively involved, and later, after the lung on this side had expanded satisfactorily, a thoracotomy was done by rib-resection on the opposite side. The patient had a gratifying convalescence and a complete recovery.

TABLE III

Type of Operation

	Rib Resection	Trochar and cannula or I tube	Aspiration	Intercostal drainage and later resection	Resection and counter drainage
Recovered.....	63	20	1	6	0
Died.....	6	1 open and 1 closed	1	0	1

Anæsthesia.—Table IV shows the type of anæsthesia employed.

TABLE IV

Anæsthesia	Cases
(Local Novocain).....	58
Nitrous Oxide.....	22
Ether.....	10
Ether, nitrous oxide and oxygen.....	3
Local and nitrous oxide.....	2
Local and ether.....	2
Not stated.....	3

EMPYÆMA OF THORAX

Local infiltration with novocain solution was generally considered to be the choice method of anæsthesia. The patients who received ether were all among the first in the series. In some instances general anæsthesia was resorted to because the patients were too apprehensive.

Of the ten patients who died seven had local anæsthesia. One had nitrous oxide and two had ether. The one who had nitrous oxide died eight hours after the operation. Of the two who had ether, one died three days and the other one month after the operation. In none of these cases did the anæsthetic seem to be a factor in the cause of death.

Post-operative Treatment.—The post-operative treatment has been fairly simple. Frequency of dressings was determined by the amount of drainage and temperature, a rise in the latter suggesting at times the plugging of a drainage tube and the consequent retention of pus. Irrigation of the pleural cavity was not employed regularly. In seventy patients there were no irrigations or instillations of fluid into the cavities. In thirty patients these treatments were carried out and consisted chiefly of Dakin's solution usually $\frac{1}{2}$ per cent. (seventeen cases); normal saline (seven cases); iodine fluid drams 1 to fluid ounces 1 (two cases); gentian violet (two cases) and mercurochrome $\frac{1}{2}$ per cent. (two cases). There is not much to substantiate that these treatments were of any particular benefit as long as the drainage tubes were open.

Most of these patients showed general improvement of strength and weight. Tonics were given and an accurate record was kept in most cases of the weight. Generous diets were permitted and the patients were often wrapped up well and the bed moved into the sun and air when the weather permitted.

The tubes were removed early, washed, and easily reinserted, gradually reducing the number of tubes (usually there were two), as well as the size and length.

The inflation of toy balloons and the blowing of fluid from one bottle into another was encouraged early, particularly if there was general improvement. To further augment lung expansion the patients were permitted to sit on the side of the bed or on a chair as early as the seventh or tenth day.

Routine blood counts and X-rays of the chest were taken.

Transfusions were resorted to in an increasing frequency. The direct type of transfusion was the one usually given. Several of the patients received three transfusions. These were not given for hæmorrhage but to counteract the definite anæmia so often seen in this disease, and particularly if it has been of long standing.

It is of significance that the private patient was discharged earlier than the ward patient, no doubt due to the fact that the general admitting condition was better, and further, the care at home after the operation could be counted upon to be better than that of the charity patient.

The average stay in the hospital, exclusive of the patients who died, was one month and eighteen days.

TABLE V
Complications

Type	Cases	Type	Cases
1. Meningitis.....	1	11. Acute otitis media.....	4
2. Gastroenteritis.....	1	12. Vaginitis, gonococcic.....	1
3. Peritonitis.....	1	13. Herpes facialis.....	1
4. Syncope attacks.....	1	14. Hiccoughs.....	2
5. Conjunctivitis.....	1	15. Chronic otitis media.....	2
6. Bronchial fistula (temporary)....	5	16. Decubitus.....	1
7. Infected finger.....	1	17. Paronychia.....	2
8. Marked anæmia.....	12	18. Whooping cough.....	4
9. Scarlet fever.....	3	19. Epistaxis.....	1
10. Furunculosis.....	6	20. Chronic nephritis.....	1
		21. Osteomyelitis of right hip.....	1

Immediate Results.—Of the 100 cases there were ten deaths. Forty-four were discharged with the wound completely healed. Twenty-four were discharged with slight drainage from a granulating sinus. All of them were well advanced in healing. Twenty-two were discharged with drainage material, chiefly a rubber tube, still in the pleural opening.

Late Results.—At this writing, of the ninety who left the hospital alive, eighty-two answered that they were well and active. Two were draining with recurrences. Two are dead, one having died of diabetes and another of apoplexy, but both had completely recovered from the empyæma a number of years prior to their demise. Four could not be traced.

Of the twenty-two patients who had been discharged with drains still in use, the average healing was two months and three weeks with the exception of one. In this case the healing was delayed for three years, during which time she was in Colorado for tuberculosis. She has now been entirely well for over two years.

Recurrences.—In the present series there are six cases where chronic or recurrent empyæma followed. Two were adults, one forty-four and the other fifty-nine years of age. The one had six recurrences and was drained an equal number of times and has had a drainage tube for the last three months. The primary operation was an intercostal drainage with a rubber tube without rib-resection. The other had two recurrences since his primary operation, which consisted of a rib-resection. Both times he recovered promptly.

The other four recurrences were in children. All of these had only one recurrent attack and since then all of them have been apparently healthy and well. One of these had only an intercostal rubber tube drainage for the first operation, but at the recurrence had a rib-resection with exploration of the cavity. Another one had an intercostal drainage followed in three weeks by a partial rib-resection. Two of them had a partial rib-resection as their primary operation.

Deaths.—No. 1.—Girl, fourteen years, temperature on admission 102°, pulse 120, respiration 35. Pain in right side of chest for fourteen weeks. Associated with this were

EMPYÆMA OF THORAX

headaches, coughing and chills. Her temperature was septic and gradually she failed in strength and lost considerable weight. Marked dullness on the right side of the chest anteriorly and posteriorly. Aspiration gave thick pus containing pneumococci and staphylococci. The day after admission 3 centimetres of the eighth rib in the posterior axillary line was removed and two rubber tube drains inserted. The immediate reaction was satisfactory but there was gradual failure in strength. Some sepsis continued, occasionally there was vomiting and toward the end there were frequent involuntary stools. Death occurred one month after the operation. No post-mortem examination.

No. 2.—Female, fifteen years. She was sick at home one week. On admission to the hospital her temperature was 103°, pulse 124, respiration 38. There was dullness over the left chest anteriorly and posteriorly. Diagnostic aspiration done. Ten days after admission aspiration was positive for pus which contained many streptococci. A rib-resection was done the following day. A large amount of pus was released. Three tubes were inserted. Poor reaction followed the operation. Death three days later. No post-mortem examination.

No. 3.—Male, twenty-eight years. Pleurisy was his first complaint. He was admitted to the hospital two weeks after the onset of the trouble. Temperature was 98°, pulse 130, respiration 28. Diagnostic aspiration revealed pus. No particular organism was isolated. The same day 2 centimetres of the eighth rib in the posterior axillary line was removed. Much pus was evacuated and two rubber drainage tubes were inserted. The patient did not rally and died eight hours later. No post-mortem examination.

No. 4.—Male, nineteen years. Started with severe pain on the left side of the chest, front and back. Gradually this became better. As time went on his temperature came down, but at the end of one month he began to get short of breath, persisted in having some temperature and occasionally expectorated purulent fluid. On admission his temperature was 103°, pulse 100, respiration, 35. Admission one month after inception of thoracic pains with dyspnea. Marked limitation of motion on the left side of the chest, over which area there was also dullness to percussion. The right side of the chest was hyper-resonant. Aspiration in the eighth interspace in the posterior axillary line gave 750 cubic centimetres pus. Staphylococci were isolated. X-ray showed marked pleural effusion on the left side. Three days after the aspiration an intercostal tube was inserted and 2000 cubic centimetres of pus again obtained. The convalescence was fairly satisfactory during the first month, but with the beginning of the second month he gradually lost ground. The drainage tube was left in place and was open. Toward the end his temperature became subnormal with the pulse ranging between 110 and 120 and the respiration between 20 and 25. Death occurred one month and twenty days after operation.

No. 5.—Male, forty-nine years. Had been in the hospital three weeks for the repair of an inguinal hernia. Toward the close of his convalescence, which was otherwise uneventful, he developed a slight cold, but insisted on going home. Shortly after returning home the cold became progressively worse and with it there was sharp pain on the right side of his chest, at first only with breathing. This became better but he continued to have a temperature. There was some shortness of breath and loss of weight. One month after his release from the hospital he was admitted again. Temperature 101°, pulse 120, respiration, 30; limited expansion on the right side of the chest; tactile and vocal fremitus increased on the right both anteriorly and posteriorly; percussion dull over the lower half of the right chest and numerous crackling râles heard over this same area; aspiration gave pus with many streptococci. The day after admission a rib-resection was performed under local anæsthesia. Four centimetres of the eighth rib in the anterior axillary line were removed and two drainage tubes inserted. At first the convalescence was satisfactory, but soon he became weak, toxic and quite rapidly became worse and then unconscious. A spinal puncture revealed cloudy spinal fluid containing many streptococci. Patient died fifteen days after operation.

A complete post-mortem examination was made. An acute suppurative cerebro-spinal meningitis was found. The cultures from the meninges, the pericardium, and the right pleural cavity all contained streptococci in large numbers.

No. 6.—Male, fifteen months. The onset consisted of a cold, which became progressively worse, with vomiting and progressive difficulty in breathing. He was admitted to the hospital ten days after the onset. Temperature 104°, pulse 150, respiration 50. There was much lagging on the left side of the chest, marked dullness to percussion and distant breath sounds.

X-ray of the chest showed marked pleural effusion on the left side. Hæmoglobin 38 per cent, red blood-cells 3 million, white blood-cells 11,600, polymorphonuclears 80.

Aspiration gave thick greenish pus containing many pneumococci. The following day a rib-resection was done and two tubes inserted. A moderate amount of pus was released. The child did not rally very well and died eighteen hours later.

A post-mortem examination was made. The left lung was markedly collapsed and there was some compensatory emphysema on the right side. Very little pus was found in the left pleural cavity.

No. 7.—Male, nine months. The illness started with a cough, dyspnoea and fever. At the end of three weeks the patient was admitted to the hospital. Temperature 104°, pulse 144, respiration 43. Expansion on the right side of the chest poor; labored breathing. On the right there was marked dullness to percussion. There was no impairment of percussion on the left side.

Under 5 cubic centimetres of $\frac{1}{2}$ per cent. novocain solution a needle was inserted in an intercostal space, 5 cubic centimetres of pus was withdrawn. The child died very shortly thereafter.

Post-mortem examination showed a greatly enlarged pleural cavity on the right side. The cavity was filled with sero-purulent fluid approximately 700 cubic centimetres. The parietal layer of the pleura was covered with a yellowish purulent exudate. The right lung was markedly collapsed, particularly the lower lobe. The left lung showed moderate œdema and some congestion at the base.

No. 8.—Female, two years. Two months before admission she developed a fever and became restless and irritable. On admission temperature was 102°, pulse 160, respiration 55. Motion on the right side of the chest was greatly limited and percussion was dull both front and back. X-ray showed right-sided pleurisy with effusion. Aspiration gave purulent fluid containing many streptococci. Under local anæsthesia, by a small trochar and cannula, a small intercostal tube was inserted and 75 cubic centimetres of pus was withdrawn. The patient went from bad to worse and died within five hours.

A post-mortem examination was made. A small amount of pus was found in the right pleural cavity. Both lungs showed bilateral bronchial pneumonia, especially marked on the right, with some small areas of consolidation found especially at both lung bases. Abdominal examination negative.

No. 9.—Male, six years. Three weeks before admission to the hospital he developed a cold in the head with a slight cough and occasional pain in the left ear. Two weeks after the onset he developed chills and was more feverish. The child remained toxic and began to lose weight and strength. Admitted with a temperature of 102°, pulse 125, respiration 38.

X-ray examination showed effusion on the left side of the chest. Percussion note was dull over the entire left chest. Moist râles were also heard. Aspiration gave pus containing streptococci and pneumococci. Under local anæsthesia, part of the fifth rib in the mid-axillary line was resected and drainage tubes inserted. There was profuse drainage. The child did not rally and died the same day.

No. 10.—Boy, eight years. Had influenza pneumonia, which for a little while seemed cleared up, but there was a return of temperature with pain in the chest, dyspnoea and loss of weight and strength. On admission to the hospital temperature was 101°,

EMPYÆMA OF THORAX

pulse 140, respiration 30. The general appearance was that of toxicity. There was deficient expansion on the left side of the chest where also the percussion note was markedly impaired. Aspiration gave pus, which contained many streptococci. Hæmoglobin 75 per cent., red blood-cells 4,150,000; white blood-cells, 20,000; polymorphonuclears 87 per cent. Under local anæsthesia rib-resection was done with counter-drainage at a lower level. Much pus was obtained and three drainage tubes were inserted in the posterior axillary line. The patient continued to have septic temperature and pulse, with also some distention of the abdomen. This continued three weeks when the temperature increased as did also the distention and pain in the abdomen. The patient died one month after the operation.

A post-mortem examination was made and showed a diffused suppurative peritonitis; subsiding empyæma (left) and traumatic injury to the diaphragm.

Comparison with Other Statistics.—A comparison with other statistics may be made.

Reinhoff and Davison,⁷ in a study of empyæma in children under two years of age in the Johns Hopkins Hospital from 1889 to June, 1927, report a mortality of 29.2 per cent. in twenty-four children treated by the open method with rib-resection, and 50 per cent. in twenty-two treated by trochar cannula. They are of the opinion that better results can be obtained by the use of one operation, the open thoracotomy in all cases.

Hart,³ from the same institution, working on the patients in the twenty months following the above series and patients of all ages, used his closed method of tidal irrigation and suction. Fifty patients were treated, five died in the hospital, giving a 10 per cent. mortality.

Binney,¹ using a closed method, either trochar and cannula of the intercostal type or rib-resection and then closure with tight suturing of muscles around the tube, had a mortality in 100 cases of infants, children and adults, of 13 per cent. Twenty-one patients required a second operation.

Hudson⁵ reporting eighty-six cases treated in children reports an 18.7 per cent. mortality in thirty-two cases treated by intercostal drainage and a 12.5 per cent. mortality in the remaining forty cases treated by the open rib-resection method. Of the twenty-one cases treated by the closed method fourteen later required a rib-resection. He concludes that rib-resection in children, as a primary operation in selected cases, or preceded by repeated aspiration or intercostal closed drainage during the synpneumonia stage is a valuable therapeutic procedure.

Farr and Levine² report 226 cases treated by the open method using rib-resection in 168 cases with thirty deaths, a mortality of 18 per cent. Intercostal incision with open drainage was employed in fifty-eight cases, with nineteen deaths, a mortality of 35 per cent.

McEney and Brenneman⁶ report a series of thirty-three children treated by repeated aspiration only. Three died, giving a mortality of 9 per cent. The average stay in the hospital was three and one-half months as contrasted with two and one-third months for children treated by them the previous year when they used the open method. They are guarded in their conclusions and do not recommend aspiration only as a routine for all cases in children.

CONCLUSIONS

(1) The 10 per cent. mortality, while it compares favorably with the mortality at other institutions where patients are treated similarly, or by different methods, still leaves plenty of room for improvement.

(2) The open method of treatment either by rib-resection or intercostal drainage after the diagnosis is established clinically, röntgenologically and by

diagnostic aspiration is an expedient method of treatment. This is particularly true in a hospital where the assistant and nursing staff are on a rotating system.

(3) It seems certain that too quick drainage is definitely more harmful than good. An acute pneumonic process should have been given ample time to subside. Again, in a very ill patient, where drainage is indicated, the decompression should be gradual, by aspiration, by closed intercostal tube drainage, and later, if indicated, by rib-resection with finger exploration of the cavity and insertion of open tubes.

(4) In an old primary empyæma where the patient has well compensated himself to the condition, not much is gained by anything else except partial rib-resection.

BIBLIOGRAPHY

- ¹ Binney, Horace: A Study of 100 Cases of Empyæma Treated by a Closed Method. Boston M. and S. J., vol. cxc, pp. 1206 and 1214, 1924.
- ² Farr, C. E., and Levine, M. L.: Empyæma in Children; A Preliminary Report. Surg. Gynec., and Obst., vol. xlvi, p. 79, 1928.
- ³ Hart, D.: Empyæma Treated by Tidal Irrigation. Arch. Surg., vol. xix, p. 1732, 1929.
- ⁴ Hill, L. W.: A Note on the Complications of Pneumonia in Infants and Children. Boston M. and S. J., vol. cxcvi, p. 107, January 20, 1927.
- ⁵ Hudson, H. W.: Treatment of Acute Empyæma in Children. New England J. Med., vol. ccii, p. 853, 1930.
- ⁶ McEnery, and Brenneman: Aspiration in Empyæma of Children. J. Am. Med. Assn., vol. xciii, pp. 362-367, August 3, 1929.
- ⁷ Reinhoff, W. F., and Davison, W. C.: Empyæma in Children under Two Years of Age. Arch. Surg., vol. xvii, pp. 676-688, 1928.

ORBITAL MYOSITIS AND CHOKED DISC IN EXOPHTHALMIC GOITRE

BY JONAS S. FRIEDENWALD, M.D.

OF BALTIMORE, MD.

FROM THE WILMER OPHTHALMOLOGICAL INSTITUTE OF THE JOHNS HOPKINS UNIVERSITY AND HOSPITAL

IN A recent article Naffziger* has reported a case of progressive exophthalmos following thyroidectomy in which, on operation, the extra-ocular muscles were found to be greatly thickened, œdematous, and fibrous. A fragment of one of the affected muscles was excised and sectioned. On microscopical examination, the muscle fibres were found to be degenerated, and in part replaced by fibrous tissue, the interstitial tissue was œdematous, and contained focal accumulations of lymphocytes. Reports of similar cases, without histological notes on the extra-ocular muscles, are to be found in the literature. The most recent of these is by Stewens,† who has reviewed the literature up to date, and added one new case to those already reported. Common features of the cases previously reported have been that the exophthalmos continued to progress when the basal metabolism had been reduced to normal or that the exophthalmos was altogether disproportionate to the remaining degree of hyperthyroidism, that the exophthalmos was associated with orbital and conjunctival œdema, with paralyses of the extra-ocular muscles, and with choked disc and marked visual impairment.

Naffziger's discovery of what appears to be the specific histological lesion in this type of case raises the question as to whether or not the ordinary mechanism of exophthalmos in hyperthyroidism may be of a similar nature. In order to find the answer to this question, the orbital tissues of cases of exophthalmic goitre that had come to autopsy in the department of pathology of the Johns Hopkins Hospital were examined. In all, six cases were found in which sufficient orbital tissue had been preserved to make possible the histological study of the extra-ocular muscles. Of these five showed no lesions whatsoever in their extra-ocular muscles. These five were cases of ordinary hyperthyroidism showing no complications of interest in this connection. In the sixth case, lesions of the extra-ocular muscles were found similar to those described by Naffziger. The clinical history of this case was so remarkable as to merit brief report.

The patient was a white man of fifty-four years who came to the eye clinic of this hospital in May, 1924, complaining of pain, dimness of vision, and swelling in his left eye. His past history was without interest. Four months prior to his admission to the clinic, he had had a "cold in the head" accompanied by fever and malaise. One week later, he

* Naffziger, H. C.: *Progressive Exophthalmus, Following Thyroidectomy, Its Pathology and Treatment*. ANNALS OF SURGERY, vol. xciv, p. 582, 1931.

† Stewens, H.: *Progredienter Exophthalmus nach Basedowoperation. Ueber Beziehungen zwischen Thyreoidea und Hypophyse*. Zeitsch. f. Augenheilk., vol. lxxv, p. 137, 1931.

had become unconscious and had had numerous convulsions. After four days he had regained consciousness, but remained drowsy and complained of diplopia. A swelling developed over his left eye, and there was a purulent discharge from his nose. During the following two months, he improved somewhat, but later pain, lachrymation, swelling and tearing of the left eye had developed in increasing severity.

On admission to the hospital, the general physical examination revealed no constitutional disease. The patient was moderately undernourished, the thyroid just palpable; pulse, 80-90; temperature, normal; no tremor; white blood count, 7,900; hæmoglobin, 84 per cent.; urine, normal; blood Wassermann, negative. Ophthalmological examination by Dr. Alan Woods showed the vision of the right eye with correction to be 20/40, left eye 10/100. The left conjunctiva was congested, the eye slightly proptosed, with a swelling of the tissues above the eyeball, and limitation of upward and of inward rotation of the left eye. The pupils were equal but reacted sluggishly to light. The right optic disc showed blurred margins, the left was definitely protruding. X-ray of the



FIG. 1.—Orbital myositis in exophthalmic goitre.

sinuses and rhinological examination revealed no abnormality. The clinical impression of those seeing the patient at this time was that he had an orbital cellulitis, possibly an orbital abscess, possibly a brain abscess. Ten days after his first examination, it was for the first time noted that he had slight exophthalmos of the right eye. Lumbar puncture was suggested, but refused, and the patient left the hospital early in June.

He returned September 4, 1924, stating that his general health had improved since leaving the hospital until ten days previously when his left eye had become more inflamed, and his vision had begun to fail rapidly. He had lost much weight in the interval. His pulse was now 116, the thyroid definitely and symmetrically enlarged, white blood count 8,900. There was bilateral exophthalmos, the left eye being more prominent than the right. The left conjunctiva was congested and swollen. There was an ulcer of the cornea, and the appearance of an orbital cellulitis.

Basal metabolism was now found to be +60 per cent., but both Doctors Dandy and Woods, who were much interested in this case, thought that there was strong probability of an intracranial lesion, and Dr. Arthur Bloomfield was of the opinion that the hyperthy-

EXOPHTHALMIC GOITRE

roidism alone could not account for the exophthalmos. The blood Wassermann was again found negative, spinal fluid showed no abnormality, X-ray of the skull was negative. Three days after admission to the hospital, the patient became wildly delirious, and his heart began to fibrillate. Two days later, he developed bilateral acute glaucoma. In view of his maniacal state and fibrillating heart, no radical operation for the glaucoma could be performed, but a bilateral paracentesis of the anterior chambers was done resulting in relief from this symptom. The patient, however, rapidly went downhill with increasingly rapid pulse, continued delirium, cardiac failure, and died ten days after the operation, a little over eight months after the onset of his symptoms.

At autopsy, the thyroid was found to show the typical hypertrophy of hyperthyroidism. The other viscera were normal except for minor unrelated lesions. The brain, including the hypophysis, was normal both on gross and microscopical examination. No abscess was found in either orbit, and the gross appearance of the extra-ocular muscles was not abnormal. Recent review of the preserved histological slides of this case (Fig. 1) confirmed the above findings, but the sections of the orbital tissues revealed definite lesions of the type described by Naffziger.

There was no inflammatory reaction in the loose tissues of the orbits. The extra-ocular muscles of both orbits showed marked atrophy, with fibrosis of the fibre bundles. Many fibres had disappeared, and were replaced by fat. In the interstitial tissue, there were focal accumulations of lymphocytes at times presenting the appearance of definite lymph follicles with germinal centres. There was, however, no definite oedema either of the muscle fibres or of the interstitial tissue, or of the loose tissue of the orbits in general.

DISCUSSION.—The literature on exophthalmic goitre is so voluminous, and contains the occasional reports of so many different lesions characteristic of the disease from those occurring in accidental association with it. Atrophy and fatty degeneration of the skeletal muscles have been frequently noted, and generally attributed to the wastage of the skeletal muscles, however, do not present disuse. The typical lesions in the heart muscle in this case. Various changes have, also, been described in the orbital muscles in hyperthyroidism, but none has been found to be characteristic of the disease.

It seems clear that the case just reported is allied to that reported by Naffziger, though, in Naffziger's case, the progressive exophthalmos followed after thyroidectomy, while, in the present case, the orbital trouble apparently preceded the hyperthyroidism by several months. It is of interest that no abnormality was found in the hypophysis, though Stevens attributes the symptoms in his case to a lesion in this gland. It seems, likewise, clear that the orbital myositis in Naffziger's case, and in the case just reported, is not a part of the ordinary picture of hyperthyroidism. The condition appears to be a separate disease entity in which lesions of the extra-ocular muscles are associated with abnormal function of the thyroid gland, but are not dependent upon an increased basal metabolism.

PERINEPHRITIC ABSCESS

BY CHARLES C. HIGGINS, M.D., AND N. FREDERICK HICKEN, M.D.

OF CLEVELAND, OHIO

FROM THE CLEVELAND CLINIC

ALTHOUGH perinephritic abscess has been recognized since the time of Hippocrates it still presents interesting diagnostic and therapeutic problems. Any disease which defies clinical recognition in 32 per cent. of the cases and depends on post-mortem findings for diagnosis, certainly warrants study.¹ When the operative mortality for such a common disease reaches 19 per cent., which is the average for the five largest series reported, it is evident that, in many cases, we have failed to recognize the pathological processes until they are so far advanced that the patient is in a critical condition.

In view of the above considerations, we offer here a detailed study of thirty-two cases of perinephritic abscess, in the hope of stimulating interest in this subject.

Classification.—In 1839 Rayer² introduced the term “perinephritis” to designate an inflammatory reaction of the perirenal fat or adipose capsule. He suggested that these infections be classified according to their etiology as follows: (1) Primary perinephritic abscesses or those in which the infection develops in the perirenal fat *per se*; (2) secondary perinephritic abscesses or those arising from the kidney, the adjacent viscera or some distant primary focus. Since that time, several attempts have been made to classify perinephritic infections but the resulting nomenclatures have merely added to the confusion. In Israel’s³ anatomical classification the term “epinephritis” was reserved for inflammation of the perirenal fat, the term “perinephritis” for involvement of the fibrous capsule, and the term “paranephritis” for inflammation of the pararenal or retrorenal fat. While this classification is anatomically correct, these various types cannot be differentiated clinically and therefore the above classification has been discarded.

In more recent years Hunt,⁴ Braasch,⁵ and Habein⁶ have carefully studied the etiology of perinephritic inflammation and they seriously doubt the existence of a primary perirenal abscess *per se*; they maintain that this condition always arises from some previous focus. The above-named authors suggest that if all such perinephritic infections are secondary to other systemic foci, they should be classified as being either of a renal or a nonrenal origin. This nomenclature permits the correlation of clinical and pathological findings and is not difficult of application.

Anatomical Considerations.—In order to obtain a clear concept of the pathogenesis of perinephritic abscesses we must be familiar with the anatomy of the kidney and the perinephrium.

The parenchyma of the kidney is completely covered by a thin, fibrous capsule from which delicate fibres pass into the renal cortex. When this fibrous capsule reaches the

PERINEPHRITIC ABSCESS

hilum it extends along the renal vessels as a protective sheath. The kidney is embedded in a mass of fatty tissue, called perirenal fat, which is relatively thin about the upper half of the kidney, accumulates at the hilum, is fairly abundant at the lower end, and is thickest over the posterior aspect at the lower pole. As the function of this perirenal fat is entirely protective, the reason for its anatomical position is evident. This fatty capsule is not present at birth, and is more or less deficient until puberty. Miller⁷ maintains that it varies in amount in individuals and rapidly disappears during emaciation.

The kidney and perirenal fat are enclosed in a sheath of fibrous tissue, which is continuous with the subperitoneal fascia and is called the fascia of Gerota (fascia renalis). At the outer border of the kidney the fascia is divided into an anterior and posterior layer. The anterior layer is carried in front of the kidney and its vessels, and is continuous over the aorta with the corresponding layer on the opposite side. The

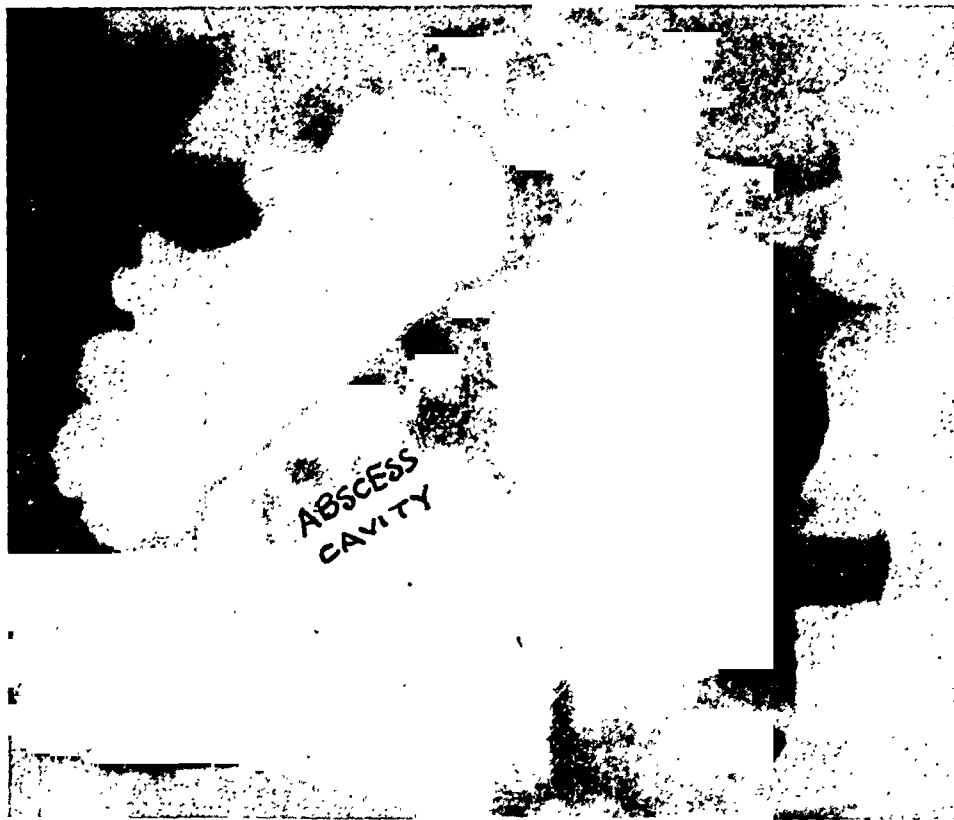


FIG. 1.—Röntgenogram showing a large hydronephrosis with a visualization of a coëxisting perinephritic abscess.

posterior layer extends inward behind the kidney and fuses with the fascia of the quadratus lumborum and psoas muscles. Above and laterally, the sheath joins the fascial lining of the diaphragm and transverse muscles respectively. Below, the two layers remain separate for a short distance and then fuse.

These fascial coverings of the kidney are very important as they determine the direction in which a perinephritic abscess may extend. Small fibrous trabeculae join the fascia renalis to the true renal capsule by traversing the perirenal fat. The adipose tissue is practically avascular, having a very meagre blood supply.

According to Gerota⁸ and Zuckerhandl,⁹ the lymphatic vessels of the kidney form three plexuses; one in the renal parenchyma; one beneath the true renal capsule, and a third in the perinephric fat. The subcapsular and fatty tissue plexuses anastomose very freely, thus affording a means of spreading infection. The lymph-vessels of the kidney and the perinephrium drain into the lateral aortic nodes which also receive drainage from the lower genito-urinary tract and bowel.

From the foregoing brief anatomical review, we find (1) that the perinephric tissue

is encased in a fibrous capsule; (2) that this area has a low resistance to infection owing to its meagre blood supply, and (3) that lymphatics of the adipose tissue anastomose with those of the kidney, thus offering a route for bacterial invasion.

Etiology.—Pyogenic bacteria reach the perirenal tissues by (a) direct extension from an infected kidney or adjacent tissue, (b) by lymphatic dissemination from a primary focus, or (c) by hæmatogenous metastasis. At times we are able to trace the mode of infection but in many cases our studies are inadequate to reveal the primary source and we term the infection cryptogenic.

The fact that renal disease can produce perirenal infection is well established, pyonephrosis, nephrolithiasis, renal tuberculosis and cortical abscess being the most common offenders in this regard. (Fig. 1.) In 230 cases of perinephritic inflammation, renal disease was found by Kuester¹⁰ in 26 per cent.; by Braasch⁵ in 55.4 per cent.; by Hunt⁴ in 44.6 per cent.; by Miller,⁷ 20 per cent.; by Albarrans,¹¹ 50 per cent.; and by Israel,³ 79 per cent. Guiterras¹² is very emphatic in asserting that practically all infections of the perinephrium arise from the kidney; in his series of fifteen cases a definite renal disease was present in fourteen. In our series of thirty-two cases the kidney was involved nineteen times. (Table I.) However, all the nephritic infections were not primary in the kidney but some were secondary to systemic foci.

TABLE I

Types of coëxisting renal disease found in our series

Pyonephrosis	10
Nephrolithiasis	3
Tuberculosis	1
Carbuncles	1
Multiple cortical abscesses.....	2
Duplex kidneys with infection.....	2
Condition not determined.....	13

When the kidney becomes infected, whether the infection is due to calculi, hydronephrosis, or injury; or whether it is ascending or hæmatogenous, pyonephrosis may result. The parenchyma is invaded, multiple abscesses are formed, and in many instances the cortex is studded with small localized areas of inflammation. These suppurative cortical areas may rupture and produce a perinephritic infection. Hunt⁴ maintains that most perirenal infections arising from primary peripheral lesions such as felons, carbuncles, dental infection, osteomyelitis, and parotitis, are preceded by cortical abscesses of the kidney. Richardson¹³ collected 108 cases of perirenal abscess due to metastatic renal infection and found that in thirty-three cases a renal carbuncle preceded the inflammation of the perinephrium.

It is a common experience to open a perinephritic abscess and be unable to demonstrate any communication with the kidney. Even the closest scrutiny may fail to reveal a ruptured cortical abscess or a fistulous tract to the interior of the kidney. Miller⁷ believes that the infection spreads from the kidney

PERINEPHRITIC ABSCESS

to the perinephrium by means of the lymphatics, as Zuckerhandl,⁹ and Gerota⁸ have demonstrated an anastomosis between the subcapsular and subserous lymphatics.

Although we agree that renal disease causes perirenal infections, it must be remembered that the incidence of perirenal infections is not very high. In 2,680 nephrectomies performed at the Mayo Clinic, perinephritic abscesses were demonstrated in only 1.5 per cent., and all of these cases represented advanced renal lesions. All cortical abscesses do not rupture and produce inflammation in the perinephrium but many of them subside spontaneously. Renal tissue has regenerative power as is evidenced by the healing of cortical abscesses following simple incision and drainage of the perirenal abscess.



FIG. 2.



FIG. 3.

FIG. 2.—Flat plate of kidney showing a calculous pyonephrosis. At operation an associated perinephritic abscess was found which did not show in the röntgenogram. Barium is visualized in the large bowel as the result of gastro-intestinal studies.

FIG. 3.—Pyelogram made in above case showing a calculous pyonephrosis; no evidence of the coexisting perinephritic abscess is seen.

At autopsy we have found renal abscesses in various stages of formation and regression. Some were large and necrotic, others were small and well localized; some were undergoing the process of autolysis and others were being absorbed and the damaged renal parenchyma replaced by cicatricial tissue.

In performing nephrectomies for renal disease we often encounter badly damaged kidneys embedded in healthy adipose tissue, indicating that not all renal infection extends to the perinephrium. Probably carbuncles of the kidney give rise to a greater number of perinephritic infections than any other single lesion but are difficult to demonstrate.

Perinephritic infection due to extrarenal disease may result from suppurative foci in any part of the body. Systemic diseases such as appendicitis, cholecystitis, ulcerative colitis, osteomyelitis, pneumonia, influenza and typhoid.

or local infections such as felons, boils, furuncles, and abrasions, may all be precursors of perirenal inflammations. Hunt⁴ collected 160 cases of perinephritic abscess, in 85 per cent. of which the primary source was a peripheral lesion. Harzbecker¹⁴ had 32, Birdsall¹⁵ 11, Rhen¹⁶ 6, and Richardson¹³ 108 cases of perinephritic inflammation which were directly due to a metastatic peripheral infection.

Miller⁷ maintains that the lower genito-urinary tract and bowel may be a source of infection before the kidney becomes involved. He points out that some of the lymphatics of the bowel, prostate, bladder, urethra, and uterus, drain into the lateral aortic nodes, which also receive lymph-vessels of the perinephrium, thus offering a direct path for bacterial invasion. In support of his contention, we find perinephritic abscesses reported as sequelæ of an abortion (Murphy¹⁷); acute orchitis (Jordan¹⁸); following gonorrhœa (Israel,³ Ransohoff,¹⁹ Jaffe,²⁰ Hagner²¹); and post-partum as in Horsley's²² three cases. In one of our cases a dilatation and curettage was performed for uterine bleeding and retained placenta. Two weeks later the patient complained of pain over the right kidney and at operation a large perirenal abscess was found. While Miller⁷ maintains that these abscesses are the result of lymphatic dissemination it seems logical to infer that many of them may be of a hæmatogenous origin.

Bacteria.—Any pathogenic bacteria gaining entrance to the perirenal tissue are capable of setting up an infection providing they are given the proper environment. Staphylococcus, streptococcus, gonococcus, pneumococcus, tubercle bacillus, typhoid bacillus, *Bacillus coli* and Actinomyces have been reported. If the abscess is secondary to metastatic infection, generally staphylococci will be found; if the abscess is secondary to simple pyonephrosis then *Bacillus coli* may be present and in some cases mixed infections are encountered. The following table indicates the various types of organisms which were encountered in this series.

TABLE II

Organisms Cultured from Perirenal Pus

Staphylococcus	9
<i>Bacillus coli</i>	3
Streptococcus	2
<i>Bacillus coli</i> and streptococcus.....	1
<i>Bacillus coli</i> and straphylococcus.....	1
No cultures.....	15
Negative culture.....	1

Age and Sex Incidence.—Perinephritic abscess may occur at any period of life, but is usually found in individuals between the ages of twenty and forty years. In our series, the youngest patient was three months old and the oldest seventy-four years; the average age was thirty-four and a half years. Infections of the perinephrium are uncommon in children because the perirenal fat does not become fully developed until puberty. However, Campbell¹ reports a case of a child in whom a staphylococcic infection of the

PERINEPHRITIC ABSCESS

thumb developed seven days after birth; the felon was incised and six days later the child died. Autopsy revealed multiple cortical abscesses of both kidneys with an early perinephritic abscess on one side. Table III represents the age distribution in our series.

TABLE III

Under 20 years.....	I case
20 to 40 years.....	15 cases
40 to 60 years.....	11 cases
60 to 80 years.....	2 cases
Age unknown.....	3 cases
Youngest	3 months
Oldest	74 years
Average	34.5 years

Perirenal infections are more common in men than in women, perhaps on account of the fact that in men renal trauma is more common due to the strenuous character of their work. In our series of cases seventeen occurred in males and fifteen in females.

Trauma.—Trauma is an important predisposing factor in perirenal infection. The local resistance of the injured tissue is lowered, thus permitting bacterial invasion. Brewer injected bacteria into the blood stream of animals but was unable to produce perinephritic abscesses until he conceived the idea of traumatizing the perirenal tissues. The more frequent occurrence of right-sided infection is attributed to the lower position of the right kidney which renders it more liable to injury. The association of calculi with renal and perirenal infection is perhaps due to persistent injury which lowers the resistance of renal tissue.

Many cases have been reported in which the perinephritic inflammation was due to an extravasation of urine into the adnexal tissue as a result of operative injury to ureters or renal pelves. In one of our cases two pelviolithotomies had been performed for recurring stones. Following the second operation a perinephritic abscess developed with a protracted draining sinus. Table IV shows the various etiological factors which we considered to be responsible for the existing perirenal inflammation.

TABLE IV

Factors concerned in the production of perinephritic infections
Infection

Boils	4
Dental abscesses	2
Osteomyelitis tibia	1
Acute prostatitis (following massage).....	1
Carcinoma prostate with abscesses.....	1
Chronic appendicitis	1
Influenza	1
Erythema nodosum	1
Dilatation and curettage for retained placenta.....	1

Trauma

Injury to perirenal tissue.....	8
<i>Primary renal disease</i>	
Pyonephrosis	2
Nephrolithiasis	2
Tuberculosis (renal)	1
Actinomycosis	1
Not determined	5

Symptoms.—Onset—The mode of onset varies, depending upon whether the perinephritic inflammation is of renal or extrarenal origin. In those cases in which the condition is associated with chronic renal disease such as pyonephrosis or calculi, the onset is insidious and the formation of the abscess



FIG 4 —Röntgenogram showing a calculus in right kidney associated with pyonephrosis. At operation a coëxisting perirenal abscess was found.

is generally indicated by a progressive increase in the intensity of such symptoms as fever, chills, pains, and generalized malaise. In those cases in which the condition is the result of metastatic infections, whether local or general, the onset is frequently acute and sudden, with rigor, malaise, and generalized reactions which closely simulate the symptoms of a systemic infection. In three of our cases the onset was so sudden and the prostration so profound that we made the diagnosis of influenza; however, in three days the localizing symptoms suggested the presence of a perinephritic inflammation which was confirmed by operative procedures.

In the case of a perinephritic abscess of metastatic origin, the primary focus may be completely healed before the symptoms have progressed sufficiently to make a diagnosis. This latent period often confuses the diagnosis.

PERINEPHRITIC ABSCESS

tician as he is unable to find any relationship between an existing perirenal infection and a carbuncle which healed two months previously. Occasionally a perinephritic inflammation develops simultaneously with the peripheral lesion and is probably the result of an infected embolus being carried to the perinephrium.

Chills and Fever—Chills have always been considered as an initial symptom in perinephritic infections; however, in but twelve of our cases could we elicit such a history, and in these the infection was usually of a metastatic origin. The number of chills varied from one to twenty-three per day, and in one case the chills had been present for two months prior to the admission of the patient.

A fébrile reaction is the most constant symptom, and was present in all of our cases. The fever is of the intermittent type and varies between a marked hyperpyrexia and a moderate rise of temperature. When the fever is associated with chills, the patient usually has profuse drenching sweats. It is very interesting to note the rapid descent of the fever which sometimes accompanies the incision and drainage of the perirenal abscess.

A chill followed by a marked fébrile reaction, associated perirenal pains, and tenderness, is very suggestive of a perinephritic infection.

Pain—Pain is the one symptom for which the patient seeks relief. The pain usually begins as a sense of fullness beneath the twelfth rib posteriorly, gradually increasing in intensity until it becomes a dull, deep-seated continuous pain, which is almost unbearable. In only three of our cases were the pains sharp and stabbing and in four cases they were paroxysmal. The pain is always accentuated by motion because of the inflammatory reaction and spasm of the psoas and erector spinæ muscles. Most patients obtain relief by heat; morphine is seldom required.

The pain is usually localized to the costovertebral angle but may be referred to the testes, knees, hips, or abdomen. One patient complained of intense pain in the right knee but negative orthopedic examinations resulted in further investigation which revealed a small perinephritic abscess. In the case of two patients the pain was entirely abdominal, being referred to the right hypochondrium and associated with tenderness over the gall-bladder. On palpation, a deep indefinite mass could be felt which was thought to be a distended gall-bladder. An exploratory laparotomy revealed a normal gall-bladder overlying a large retroperitoneal abscess which completely surrounded the kidney.

Urinary Symptoms—It is interesting to note that in only 10 per cent. of our patients were urinary symptoms noted and in each case some associated renal disease was present such as pyonephrosis, calculus, or renal tuberculosis. Frequency, urgency, dysuria, and nocturia were the outstanding symptoms in those cases in which associated renal disease was present.

Urinary studies showed that in 55 per cent. of the patients the urine was normal except for the presence of albumin. The albuminuria might have been an expression of the fébrile reaction rather than an indication of renal

or perirenal infection. In all cases in which the urine was abnormal a definite kidney disease was present. In one case the kidney contained multiple cortical abscesses and the urine was normal. In this series we found that the urinary changes offered no aid in the diagnosis of perinephritic abscess but were of some value in determining the physical status of the kidneys. (See Table V.)

Postural Deformities—A thorough physical examination is essential to establish the diagnosis of perinephritic abscess. Peculiar postural deformities are often noted, especially in children, and may be the first sign. In five of our cases the patients could not extend the isolateral thigh because the abscess produced a spasm of the iliopsoas muscle. They walked with a peculiar flexion deformity, and when in the recumbent position the thigh was semiflexed.

A slight lumbar scoliosis can often be detected, the arch being toward the normal side; or a slight swelling or fullness in the costovertebral angle may be noted.

Rigidity and Tenderness—Abdominal rigidity was present in 50 per cent. of our cases and was suggestive in an additional 10 per cent. The rigidity may be localized to the musculature of the loin or referred to the anterior abdominal wall. Reference has been made to two cases in which the rigidity and tenderness of the right hypochondrium led to an erroneous diagnosis of gall-bladder disease.

Tenderness is usually present and varies from a slight sense of soreness to excruciating pain when the slightest pressure is exerted over the inflamed perinephrium. Brewer²³ considers tenderness to be the pathognomonic sign of a hæmatogenous infection of the kidney. Miller⁷ emphasizes that the fixed point of greatest tenderness is over the fascial triangle of Lesshaft. In all but two cases we were able to elicit tenderness on deep palpation. However, in avirulent infections the tenderness develops very slowly and in some cases cannot be demonstrated.

Mass—Careful inspection sometimes reveals the fact that the lumbar hollow is replaced by a slight fullness or bulging. In 38 per cent. of our cases we were able to demonstrate a definite tumefaction. The mass may be firm and indurated suggesting a perirenal tumor, or it may be soft and fluctuant, suggesting the presence of fluid. Large perinephritic abscesses may be present without signs of tumefaction. Guiteras¹² was unable to demonstrate fluctuation in an abscess, which on operation yielded three quarts of pus.

If the abscess lies anterior to the kidney, a retroperitoneal swelling may be produced which may be easily mistaken for an intra-abdominal tumor. In two such cases we thought the perirenal mass was a distended gall-bladder. In another case we were able to palpate a large, firm, indurated mass adjacent to the cæcum which suggested an appendiceal abscess. As the patient's urine was loaded with pus, a urological study was made which resulted in the diagnosis of pyonephrosis with a perinephritic abscess. In performing a left nephrectomy we encountered a large perirenal abscess, which had dissected

PERINEPHRITIC ABSCESS

its way across the vertebræ and great vessels, over to the right iliopsoas muscles and then became localized to the retrocæcal area.

The difference between the two sides can be accentuated by examining the patient first in the sitting and then in the standing position. If the abscess is large, the entire iliocostal curve may be obliterated. Palpation sometimes produces pitting of the tissue due to the local inflammatory œdema. Deep-seated tumors which cannot be palpated may often be outlined by percussion as the inflammatory mass produces a local increase in dullness.

Blood changes—Leucocytosis is usually present, and in only five cases of avirulent infection was it normal, the average count being 17,000. In six



FIG. 5.



FIG. 6.

FIG. 5.—Pyelogram showing actinomycosis of kidney and perirenal tissue; the pyelogram fails to show any evidence of infection.

FIG. 6.—Pyelogram showing duplex kidney with hydronephrosis of lower pole, associated with perinephritic abscess. The abscess was drained and a heminephrectomy performed.

cases in which the septic course suggested a bacteremia, blood cultures were made, all of which were negative. In those cases in which changes in blood urea, uric acid, creatinin, and serum proteins were noted associated renal disease was present, which accounted for the disturbance.

Cystoscopy and Röntgenography.—Cystoscopy with ureteral catheterization, differential renal function tests and röntgenographical studies should always be made as they occasionally reveal the existence and degree of associated renal disease. In our series, routine cystoscopic and pyelographic studies demonstrated six cases of pyonephrosis, three of nephrolithiasis, two of ureteral stricture, two of duplex kidneys with infection, one of renal and vesical tuberculosis, and four of inflammatory cystitis which were complicating an anticipated perinephritic abscess.

In this series, pyelographic studies were made in the case of twenty patients and in only four cases were we able to make a definite diagnosis of a perinephritic infection. In each of these four cases we were able to demonstrate either a renal or a ureteral fistula communicating with the abscess. However, in three instances the röntgenologist made a definite diagnosis of perinephritic abscess which additional studies proved to be erroneous.

Röntgenograms of the bladder, ureters, and kidneys made on a flat plate often contribute evidence which aids in diagnosis, and are especially valuable in eliminating diseases which are confused with perirenal infection. We have records of ten cases which were referred to the clinic by local physicians who had made a presumptive diagnosis of a perinephritic abscess. X-ray examination of the spine demonstrated advanced arthritis of the vertebrae which was responsible for their pains. A flat plate may show a high fixed diaphragm suggesting a subdiaphragmatic abscess or an empyema of the chest and thus help to clarify the diagnostic puzzle.



FIG. 7.—Intravenous urogram of a pyonephrotic kidney associated with a perirenal abscess which was not demonstrated by the urogram.

Alexander,²⁴ Beer,²⁵ and Lipsett²⁶ believe that the most valuable röntgenological finding is the obliteration of the lateral border of the psoas muscle by the overlying abscess. Campbell concurs in this view. Beer²⁵ also emphasizes the existence of a lumbar scoliosis due to the marked spasticity of the iliopsoas and erector spinæ muscles,

the spinal curvature being away from the affected side. Nichols, of the clinic, maintains that a fluoroscopic study is perhaps the most valuable single help in determining the presence of pus in the perinephrium by demonstrating a fluid curve. While cystoscopical and röntgenographical studies are valuable in determining the presence of associated renal disease it is seldom that sufficient direct evidence is found to make a diagnosis of perinephritic abscess *per se*, as demonstrated in Figs. 1, 2, 3, 4, 5, 6, and 7.

In a symptomatic review we found that fever, pain, leucocytosis, tenderness and the presence of a "lumbar mass" were the most reliable diagnostic findings. We should also attempt to determine whether the primary focus of the perirenal infection lies in a disease of the kidney, spine, abdominal viscera, or peripheral infection and we should attempt to eliminate it. To incise and drain an abscess without correcting the cause is to apply palliative therapeutics. The reason why so many perinephritic infections have been termed idiopathic is probably due to incomplete studies.

Course.—The sequelæ which may result from a perinephritic abscess are

PERINEPHRITIC ABSCESS

many. As all abscesses tend to invade adjacent tissue it is not surprising to find perirenal infections extending to other organs. In Kuester's collected series of 230 cases, thirty-four ruptured in surrounding viscera as follows:¹⁰ Into pleura and bronchi, 18; intestine, 11; peritoneal cavity, 2; bladder and vagina, 2; bladder, 1.

If the pus burrows through the external arcuate ligament of the diaphragm and enters the pleural cavity, an empyema results. It may extend into a bronchus in which case the patient expectorates purulent material. Miller⁷ does not believe that all empyemas result from diaphragmatic perforation but some arise from ascending lymphatic infection.

The abscess may rupture into the loin and form a cutaneous sinus by perforating the tissues of Petit's triangle. It may perforate the walls of the intestines and cause a thin purulent diarrhoea. We have observed one nephrocolic and one nephroduodenal fistula resulting from a perinephritic infection. The pus surrounding the kidney may penetrate the renal pelvis or the ureter, in which case a sudden profuse pyuria develops. Two patients reported to the clinic complaining of an intense pyuria and pyelographic studies demonstrated that one patient had a renal-perirenal fistula and the other a ureteral-perirenal fistula. All four cases of fistula are to be reported in greater detail at a later date. In those cases in which a perirenal abscess ruptures into an adjacent organ there is an immediate decrease in the size of the perinephric mass and the new symptoms depend on the viscus involved.

The inflammation of the perinephrium may follow any of the various muscle planes resulting in a psoas, lumbar, obturator or inguinal abscess. It is conceivable that a perirenal abscess can be absorbed and reparation made. All chronic perinephritic inflammations do not require surgery but some subside spontaneously. All surgeons are acquainted with the firm, dense fibrous adhesions which are encountered in the perinephrium indicating that some preceding inflammatory reaction has become cicatrized. Guiteras¹² reports a case of his own and cites one of Albarrans' in which a known perirenal abscess had been absorbed. Neff²⁷ and Hunt⁴ suggest that some renal carbuncles heal. In two cases we made a diagnosis of perinephritic inflammation but the patient refused immediate operative intervention. Three weeks later a simple incision was made and we encountered a subsiding inflammatory reaction; cultures showed the presence of *Bacillus coli*. However, the resistance of the perirenal tissue was so good that a spontaneous healing was well advanced when we intervened.

Differential Diagnosis.—Conditions which require differentiation from perirenal abscesses are: Traumatic rupture of the kidney, pyonephrosis, nephrolithiasis, renal and perirenal tumors, lumbar arthritis, lumbar hernias in Petit's triangle, retrocæcal appendicitis, subdiaphragmatic abscess, gall-bladder disease and tuberculosis of the spine and hip. However, a chronological history together with a complete physical and urological examination, corroborated by röntgenological studies, usually permits a correct diagnosis. Campbell¹¹ emphasizes the difficulty of making a diagnosis by showing that

out of eighty cases of perinephritic abscess, twenty-six were not recognized until autopsies were performed. In two cases he made a diagnosis of an intra-abdominal lesion, and in two other cases he suspected acute appendicitis but on exploratory laparotomy he found a perirenal abscess. In one case in which he believed a perinephritic abscess to be present operation revealed gall-bladder disease. We had similar experiences for in two cases we opened the abdomen for cholecystitis and found a perinephritic abscess. In a third case a diagnosis of hæmorrhagic renal infarcts was made but on operation a perirenal abscess was encountered. In one patient an extensive infection of the perinephrium was discovered post-mortem which could not be detected clinically in spite of complete urological examination.

Treatment.—In uncomplicated cases of perinephritic inflammation liberal incision and drainage is the treatment of choice, and the earlier the operative intervention, the better the prognosis. On two occasions we explored the perinephrium and found a definite induration of the tissues with a marked inflammatory reaction but no evidence of suppuration; drains were inserted and twenty-four hours later a purulent discharge appeared with staphylococcus grown from the culture. From the above observations it will be seen that early treatment minimizes tissue destruction.

Conservative renal surgery is the method of choice and it is surprising to see how rapidly a diseased kidney will recuperate if given an opportunity. One patient had a duplex kidney with a pyonephrosis of the lower half; a large perirenal abscess surrounded the lower pole. The abscess was drained and a hæminephrectomy performed, and the patient made an uneventful recovery; repeated urological examinations indicate a normal functioning kidney at the present time.

In cases in which a perinephritic abscess has been caused by a renal carbuncle, it has been customary to perform a nephrectomy but recent studies suggest that a more conservative procedure might be employed. Neff²⁷ recently reported a series of cases in which he enucleated renal carbuncles and after repeated urological examinations he found that the diseased kidneys regained a good function. (Table V.) He firmly believes that unless the kidney cortex contains multiple carbuncles conservative surgery is indicated. Hunt⁴ intimates that many infections of the renal cortex subside if the perinephritic abscess is drained. If urological studies show the affected kidney to be badly damaged, then a nephrectomy can be performed at the primary operation. However, many patients are so extremely ill that simple incision and drainage of the perinephritic abscess is all they can tolerate. After the general condition of the patient has improved, a secondary nephrectomy can be performed if it is indicated. In our series, incision and drainage was employed in nineteen cases followed by good functional recovery, primary nephrectomy with drainage in eight cases, and incision and drainage followed by a secondary nephrectomy in three cases; in one case hæminephrectomy was performed. It seems that conservative measures are indicated if at all possible.

PERINEPHRITIC ABSCESS

TABLE V

Urinary Symptoms and Findings

<i>Symptoms</i>	
Burning	10
Urgency	5
Hæmaturia	1
Nocturia	8

Urinalysis

Red blood cells.....	4
White blood cells.....	14
Albumin	29
Organism by smear and culture.....	12
Normal except for albumin.....	16
Not reported	2

In all cases where pus and organisms were found there was associated renal disease.

Prognosis.—The prognosis in cases of perinephritic inflammation depends on the duration of the infection and the general condition of the patient. Immediate operative intervention offers the best prognosis. In Kuester's¹⁰ review of 230 cases the operative mortality was 34.6 per cent., in Campbell's¹ 20.4 per cent., in Guiterras'¹² 20 per cent., in Miller's⁷ 14.3 per cent., and in Hunt's⁴ 6.6 per cent. In our series of thirty-two cases, in all of which operation was performed, there were two deaths, a mortality of 6.2 per cent. In our follow-up examinations, twenty-five patients were still living and free of symptoms, three had died of "kidney disease" within two years after operation and two of intercurrent infections.

Complications.—The only complications which we encountered were two cases of severe secondary hæmorrhage in which a blood transfusion was required, and one secondary operation to close a chronic renal sinus. Most of the patients had a cutaneous sinus that drained for an average of five weeks and one for as long as eight months. General medication, a healthful environment and local antiseptics facilitate healing.

SUMMARY

A clinical study of thirty-two cases of perinephritic abscess has been reported in this paper.

Etiologically, the disease may be of a renal or a nonrenal origin. Pyonephrosis, nephrolithiasis, tuberculosis, and carbuncles are the most common associated renal diseases, and bacterial metastases from peripheral and systemic foci of infection produce the nonrenal variety of perinephritic infection. Fever, pain, leucocytosis and tenderness over the costovertebral angle are the most significant symptoms and these together with a carefully elicited history often lead to a correct diagnosis.

Urinalysis is of some value in demonstrating associated renal disease but is of little importance in diagnosing perirenal disease of a nonrenal origin.

Röntgenography is useful in demonstrating the presence of coëxisting diseases, but a diagnosis of perinephritic abscess *per se*, is seldom made by this method.

The treatment is surgical and is governed by the condition of the patient, the location of the abscess, the presence of associated diseases and by complications.

Conservative measures should be employed whenever possible.

REFERENCES

- ¹ Campbell, M.: Perinephritic Abscess. Surg., Gynec., and Obst., vol. li, pp. 674-682, 1930.
- ² Rayer, P. F. O.: Traité des maladies des reins et des altérations de la sécrétion urinaire, étudiées en elles-mêmes et dans leurs rapports avec les maladies des uretères, de la vessie, de la prostate, de l'urèthre, etc., vol. iii, J. B. Baillière, Paris, 1837-1841.
- ³ Israel, cited by Albrecht, V.: Ueber metastatische paranephritische Abscesse. Beitr. z. klin. Chir., vol. i, pp. 147-167, 1906.
- ⁴ Hunt, V. C.: Perinephritic Abscess. J. A. M. A., vol. lxxxiii, pp. 2070-2074, 1924.
- ⁵ Braasch, W. E.: Perinephritic Abscess. Surg., Gynec., and Obst., vol. xxi, pp. 631-635, 1915.
- ⁶ Habein, H.: Perinephritic Abscess. Proc. Staff Meet., Mayo Clinic, vol. iii, pp. 31-33, 1928.
- ⁷ Miller, M. B.: Perinephritic Abscess: A Clinical Contribution Based on Study of 36 Cases. ANNALS OF SURGERY, vol. li, pp. 382-415, 1910.
- ⁸ Gerota: Beiträge zur Kenntniss des Befestigungsapparates der Niere. Arch. f. Anat. u. Entwickl. gesch., pp. 265-286, 1895.
- ⁹ Zuckerhandl, E.: Ueber des Fixationsapparat der Nieren. Med. Jahrb., pp. 59-67, 1883.
- ¹⁰ Kuester, E. G. F.: Die chirurgischen Krankheiten der Nieren, Stuttgart, 1896-1902.
- ¹¹ Albarrans, cited by Guiteras, *loc. cit.*
- ¹² Guiteras, R.: Urology, the Diseases of the Urinary Tract in Men and Women. Two volumes, p. 466. D. Appleton and Co., New York, 1912.
Etiology, Diagnosis and Treatment of Perinephritic Abscess, with Comment on Cases. New York M. J., vol. lxxxiii, pp. 169-178, 1906.
- ¹³ Richardson, E. P.: Perinephritic Abscess: a Review of Cases Operated on at the Massachusetts General Hospital from 1899-1913. Tr. South. Surg. and Gynec. Ass., vol. xxvii, pp. 293-306, 1914.
- ¹⁴ Harzbecker, O.: Ueber metastatische paranephritische Abscesse. Arch. f. klin. Chir., vol. xciii, pp. 957-983, 1912.
- ¹⁵ Birdsall, J. C.: Perinephritic Abscess. J. Urol., vol. xxv, pp. 405-412, 1931.
- ¹⁶ Rehn, L.: Die frühzeitige Erkennung und operative Behandlung der perinephritischen Abscesse. Ztschr. f. ärztl. Fortbild, vol. viii, pp. 317-359, 1911.
- ¹⁷ Murphy, J. B.: Perinephritic Abscess, Probably Embolic in Origin; Opening and Drainage. Surg. Clin., vol. iii, pp. 922-929, 1911.
- ¹⁸ Jordan: Ueber renale und perirenale Abscesse nach Furunkeln oder sonstigen kleinen peripheren Eiterherden. Verhandl. deutsch. Ges. f. Chir., vol. xxxiv, pp. 18-22, 1905.
- ¹⁹ Ransohoff, J.: Surgery of the Kidney, Ureter and the Suprarenal Gland. Keene's System of Surgery, vol. iv, pp. 209-212. W. B. Saunders Co., Phila., 1908.
- ²⁰ Jaffe, M.: Zur Chirurgie des metastatischen Nierenabscesses. Mitt. a. d. Grenzgeb. d. Med. u. Chir., vol. ix, pp. 613-625, 1902.
- ²¹ Hagner, F. R.: Gonococcus Infection of the Kidney with Reports of Cases. Med. Rec., vol. lxxviii, pp. 568-572, 1910.

- ²² Horsley, J. S.: Perinephritic Abscess Following Parturition. J. A. M. A., vol. 1, pp. 763-764, 1908.
- ²³ Brewer, G. E.: The Present State of our Knowledge of Acute Renal Infections; with a Report of Some Animal Experiments. J. A. M. A., vol. lvii, pp. 179-187, 1911.
- ²⁴ Alexander, B.: Die Untersuchung der Nieren und der Harnwege mit X-Strahlen. Leipzig, 1912.
- ²⁵ Beer, E.: Röntgenographical Evidence of Perinephritic Abscess. J. A. M. A., vol. xc, pp. 1375-1376, 1928.
- ²⁶ Lipsett, P. J.: Röntgen-ray Observations in Acute Perinephritic Abscess. J. A. M. A., vol. xc, pp. 1374-1375, 1928.
- ²⁷ Neff, J. H.: Eucleable Multilocular Abscess (Carbuncle) of Kidney. ANNALS OF SURGERY, vol. xciii, pp. 506-510, 1931.

TUBERCULOSIS OF THE UPPER SEGMENT OF A DUPLICATED KIDNEY*

BY WALTMAN WALTERS, M.D.

DIVISION OF SURGERY, THE MAYO CLINIC

AND

JOSEPH B. PRIESTLY, M.D.

FELLOW IN SURGERY, THE MAYO FOUNDATION

OF ROCHESTER, MINNESOTA

DUPLICATION of the renal pelvis and ureter, either completely or partially, represents one of the commonest congenital anomalies of the genito-urinary system. Although cystoscopical and pyelographical studies acquaint the examiner with the presence of such a condition, it may first be discovered at operation. (Fig. 1.) Duplicated kidneys are subjected to pathological changes similar to those of the normally developed kidneys. Since tuberculosis attacks the kidney more frequently than any other portion of the genito-urinary system, one would expect tuberculosis of the duplicated kidney to occur. However, tuberculosis is rarely seen at a stage when only one segment of the kidney has become involved. The following report is representative of such a case.

A woman, aged forty-seven years, registered at The Mayo Clinic June 3, 1931, with the complaint of pain in the right upper part of the abdomen and back of thirteen years' duration. Fifteen months before she came to the clinic, dull suprapubic distress and moderate dysuria had developed. Intermittent hematuria had occurred for two months following cystoscopical examination. She had not lost weight recently.

The right kidney was palpable and tender. There were thirty milligrams of urea in each 100 cubic centimetres of blood, and the concentration of hæmoglobin was 81 per cent. Röntgenograms of the thorax were negative. A catheterized specimen of urine contained pus, graded 4. Cystoscopical and retrograde pyelographical studies disclosed complete duplication of the right ureter and renal pelvis, without crossing of the ureters. Urine from the upper segment contained pus, graded 4, and function was markedly reduced. The lower segment functioned normally, and its urine was not infected. The left kidney responded normally to functional tests and produced clear urine. Ureteral catheters passed through both ureters without obstruction. Koch's bacillus was not demonstrated.

June 16 exposure of the right kidney revealed infection of the upper segment, involving the cortex (multiple small punctate tubercles) and the upper portion of the corresponding ureter. Right heminephrectomy was performed. (Figs. 2 and 3.) The pathologist reported tuberculosis, whereupon the remaining half of the right kidney was removed. Tuberculosis was not demonstrable grossly or microscopically in the lower portion. Convalescence was uneventful and the patient was dismissed on the sixteenth day after operation, at which time the wound was practically healed.

Braasch and Scholl² reported 144 cases of duplication of the renal pelvis and ureter observed in The Mayo Clinic; in six of the cases nephrectomy

* Submitted for publication September 15, 1931.

TUBERCULOSIS OF KIDNEY SEGMENT

was performed for tuberculosis. Although the tuberculosis was confined mainly to one segment, in four of the cases, however, microscopical examination revealed that the tuberculous process had spread to the adjacent, apparently healthy segment.

Perman,⁴ in 1923, and Boeckel and Franck,¹ in 1926, each reported a case similar to that presented here. In both cases tuberculosis was confined to the upper segment of a double kidney. In presenting their case, Boeckel



FIG. 1.—Retrograde pyelogram of right kidney. Complete duplication of pelvis and ureter may be observed.

and Franck¹ called attention to Franco's³ thesis, published in 1922, in which he reviewed from the literature thirteen cases of similar type, in six of which the condition was found at necropsy, and in five at the time of operation. In only two cases was it possible to make the diagnosis by cystoscopic examination and catheterization of the ureters. Microscopical examination to determine the presence or absence of tuberculosis was not made in all of the cases noted by Perman⁴ in the literature. Papin, in discussing Boeckel and Franck's case, related having operated with Legueu on a patient who had

advanced tuberculosis in one kidney and early infection by Koch's bacillus in one segment of the other kidney which was duplicated. Heminephrectomy on the duplicated kidney was followed by nephrectomy of the other. The patient recovered and remained in good health.

If one portion of a duplicated kidney is tuberculous, the other segment seems usually to be involved, and nephrectomy the operation of choice. On the other hand, if the process can be proved definitely to involve only one



FIG. 2

FIG. 2.—Kidney with duplicated pelvis. Upper segment shows early involvement with tuberculosis; the lower segment is free from tuberculosis.

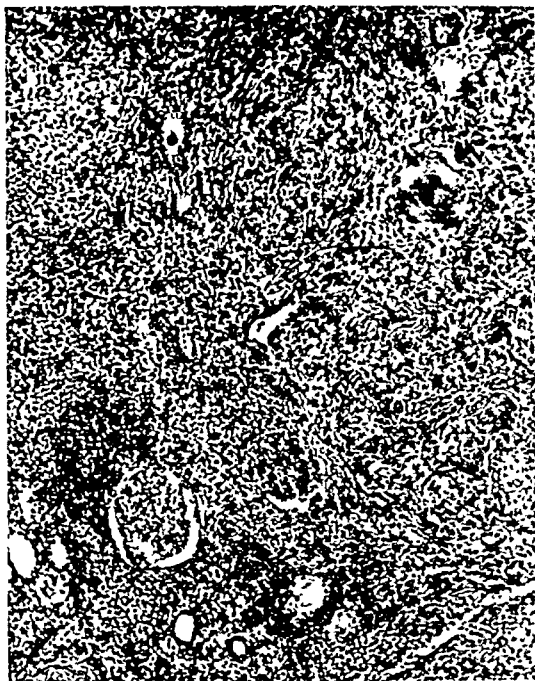


FIG. 3

FIG. 3.—A specimen taken from the upper segment of a duplicated kidney that shows a typical tuberculous process.

segment, heminephrectomy may be done if the affected segment is accessible and has its individual blood supply.

BIBLIOGRAPHY

- ¹ Boeckel, A., and Franck, A.: Tuberculose localisée au segment supérieur d'un rein à double uretère. *Jour. d'urol. med. et chir.*, vol. xxiii, pp. 54-61, January, 1927.
- ² Braasch, W. F., and Scholl, A. J.: Pathological Complications with Duplication of the Renal Pelvis and Ureter. *Surg., Gynec., and Obstet.*, vol. xxxv, pp. 401-417, October, 1922.
- ³ Franco: La duplicité urétérale envisagée au point de vue pathologique et chirurgical. Paris, 1922, 353 pp.
- ⁴ Perman, Einar: Über Tuberkulose in Nieren mit zwei Nierenbecken und Ureteren. *Acta chir. Scand.*, vol. lv, pp. 591-601, 1922-1923.

MALIGNANT TUMORS OF THE KIDNEY IN INFANCY AND CHILDHOOD *

By CHARLES G. MIXTER, M.D.
OF BOSTON, MASS.

FROM THE SURGICAL SERVICE OF THE CHILDREN'S HOSPITAL OF BOSTON

BLAND SUTTON has stated that complicated glandular organs such as the kidney and prostate are prone to develop sarcoma at all ages but more particularly in the early years of life. Certainly the kidney is the most frequent site of malignant disease in the first decade, between 20 per cent. and 25 per cent. of all malignancies occurring in this region. Although the commonest of all malignancies in childhood, it is yet a rare disease, and reports in the literature of limited series of cases have dealt largely with the pathogenesis and pathological aspects of these interesting tumors. From the larger collected series it is difficult to obtain definite data regarding the operability, the operative mortality and the expectation of cure in this seemingly discouraging group of cases. It is with the hope of throwing some light on these points rather than attempting to evaluate the theories of pathogenesis, that this series of cases has been considered.

During the past twenty-one years there have been approximately 22,000 admissions to the surgical wards of the Children's Hospital, Boston, and in the same period forty-one instances of renal neoplasm have been recorded. In the same length of time ten cases of neuroblastoma of the adrenal, five of ovarian and four of bladder malignancy appear in the records. Renal neoplasm in the child is probably encountered with one-sixth the frequency as in the adult. In our series of forty-one kidney tumors, the pathological diagnosis was embryomatous mixed tumor in thirty; in seven, various pathological diagnoses, including sarcoma, hypernephroma and malignancy of epithelial origin were given; and in four cases, though three had been subjected to exploratory operations and one to nephrectomy, no pathological report was available. It is probable that if the gross specimens were still available, further study would show that many, if not all of the seven cases in which the pathological diagnosis was unquestionably based on the preponderance of one type of cell in the given tumor, would be reclassified as embryomatous mixed tumor by the identification in other portions of the specimen of embryonic gland tubules, smooth or striated muscle fibres, cartilage or other elements characteristic of these neoplasms.

Fraser has concisely summarized three of the four principal theories of pathogenesis of the mixed tumors:

(1) That their origin is due to inclusions of Wolffian body tissue which has become displaced and persists among the cells of the developing kidney or metanephros. (Birch-Hirschfeld.)

* Read before the Southern Surgical Association, December 9, 1931.

(2) That aberrant cells of the myotome and sclerotome are responsible for the tumor growth and that the apparent mixed character is to be explained by the varying constituents which enter into the ultimate formation. (Wilms.)

(3) That these tumors are not due to inclusions from extrarenal sources, but are derived from the embryonic tissue of the true kidney, this tissue persisting and becoming metamorphosed into cellular structures of various types. (Busse, Muus, Ewing.)

A fourth theory advanced by Ribbert explains the tumor origin from a totipotent blastomere, misplaced at a state of development before the three primitive germ layers have been formed.

Gross Pathology.—The tumor masses in this series vary in weight from 100 grams to 1500 grams. They are usually round to oval in shape and are enclosed in a thick, grayish-white, connective-tissue capsule which is continuous with the external capsule of the remnant of kidney tissue. At one



FIG. 1.—Showing low-power view of embryoma of kidney. Note tumor mass separated by dense fibrous tissue from compressed kidney.

pole of the mass, often the lower, and extending slightly along one side of the mass, there is found a remnant of the original kidney, separated from the tumor by dense bands of connective tissue. The kidney tissue varies usually from a few millimetres to several centimetres in thickness and often a small amount of pelvis can still be recognized. The cortical striations stand out clearly and the cortex approximates its normal thickness. The tumor mass is usually irregular in external outline and the capsule is always tense and bulging. A few rounded nodules appear as elevated portions beneath the tumor capsule, distorting the shape of the mass. On section, the cut edges evert over the edge of the capsule. The cut surfaces of most of the tumors in this series show a striking similarity to one another. The tissue is firm, grayish-white to grayish-yellow in color, and is divided into two to four large lobules of irregular size by heavy strands of connective tissue, which can be clearly seen with the naked eye. Portions of the tumor show discol-

oration, hæmorrhage, and softening in scattered areas, varying from one to five centimetres in size. Occasionally, there is found one large lobule composed of numerous small, cystic cavities containing gelatinous material. The gross picture usually gives no indication of the particular microscopical variation of the tumor growth to be expected on histological examination. The tumor definitely arises within the kidney and shows its greatest effect upon the kidney by pressure atrophy. In one case, approximately two-thirds of the kidney remained and showed no gross or microscopical changes. It was separated from the large tumor mass above by a thick, connective-tissue capsule and such a clean plane of cleavage was present that the kidney could be separated from the tumor mass with little force, leaving behind an intact tumor capsule. More often, the normal kidney fuses gradually into the

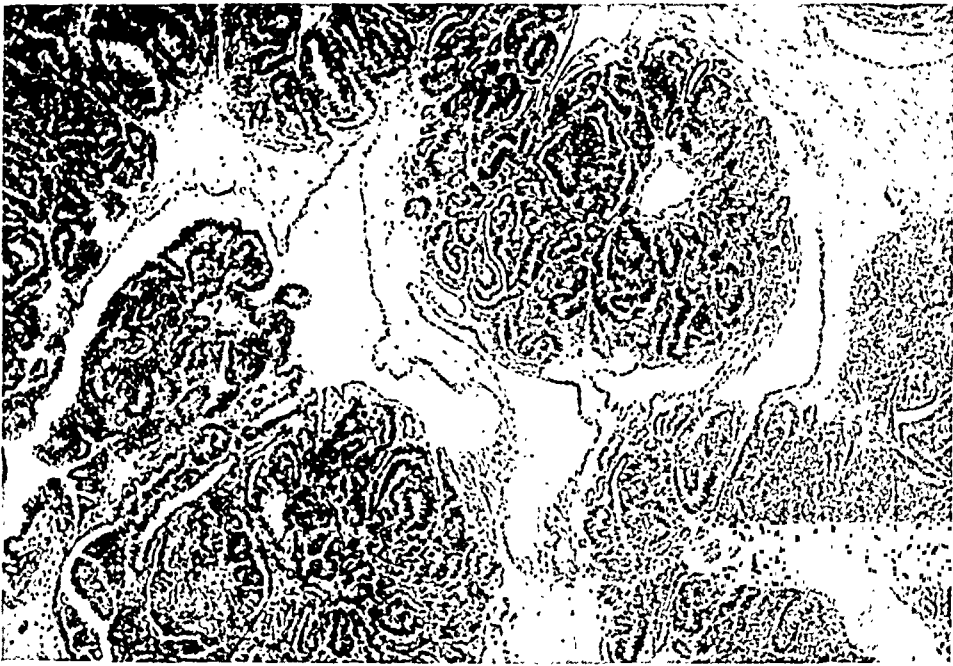


FIG. 2.—Low-power view showing glandular and papillary arrangement of tumor.

tumor. Definite boundaries can be found, however, on microscopical examination.

Microscopical Examination.—There is no one typical microscopical picture. Various types of cells in varying proportions, distribution, general arrangement, and degree of maturity are found. Two extreme pictures of the undifferentiated type are frequently noted. The first consists of large numbers of young, undifferentiated cells of the connective-tissue series which grow wildlly and with no definite arrangement. The other shows a somewhat similar picture with young, undifferentiated cells of the epithelial series. In other portions of the same tumors, large areas can be found where cells of the epithelial type are arranged in tubule formation with lining cells, one to three cells deep. These tubules are often round and sometimes elongated or irregular in shape. Occasionally, abortive glomeruli can be found. The tubular structures are usually surrounded by loose, poorly arranged, connective-tissue stroma. Often papillary ingrowths are noted in these tubular structures, and occasionally in the same field, dense masses of similar cells growing in cords or clusters without lumina may be found. The typical cell in the tubules is hyperchromatic with a moderate amount of cytoplasm. A definite

cell outline is present, and the nucleus is usually elongated and vesicular in type with a rich chromatin network. In many of the tumors in this series, striated and smooth muscle cells could be found either rarely or in abundance, and on one occasion, a small amount of cartilage and bone was present. In two tumors, the predominating type cell was the striated muscle cell, although the other described elements were also present in small amounts. The marked variation in the microscopical picture is the most outstanding feature of this tumor. All variations from masses of undifferentiated, wildly growing cells with scant stroma to a fairly well differentiated structure containing abortive tubules and glomeruli can be found. In two cases studied at autopsy, metastases were found. One showed extension paravertebrally, and the other had metastases in the liver and lungs. The kidney remnants show essentially normal renal tissue except for the consequences of pressure of the tumor on the adjacent renal structures. No extension of the tumor into the kidney remnant proper is seen.

The numerous features of gross similarity of these tumors, regardless of their size or histological pictures, suggest that they belong to one homogeneous group of tumors arising within the kidney. No one explanation of the genesis of these tumors can be applied to all of them, and the final decision as to their genesis has not yet been made. To recognize these tumors as a definite group distinct from all other tumors in the general region of the kidney, and to apply the name "embryoma" to properly designate the known facts as to their genesis and microscopical and gross pictures, would seem the best way to leave this problem. The adoption of this designation, with a qualifying remark specifying the predominant cell type, appears to be the simplest and clearest means of classifying this type of tumor. The confusing nomenclature which has arisen in the literature adds nothing but perplexity to the understanding of this tumor. The designation *sarcoma* or *carcinoma* has no justification. A prognostic statement from a gross and microscopical study of an embryoma of the kidney must be made with great caution. The histological picture of the tumors removed from patients in this series still alive shows no striking differences from the tumors in the remainder of the group. Even when tumors are seen which show a considerable degree of differentiation, and appear to be comparatively slowly growing, the prognosis cannot be hopeful with certainty, for tumors of early life, in general, are notoriously malignant in their behavior.

Difficulty may sometimes arise in microscopically distinguishing the less differentiated type of embryoma from neuroblastoma arising from the adrenal medulla. Usually, however, the neuroblastoma has a distinctive picture characterized by the presence of the large, cylindrical and pyriform cells arranged about a central mass of granular material with "rosette" formation. The central granular material can be resolved into very delicate fibrils which can be traced into the pyriform cells. The most important element in the diagnosis of the neuroblastoma is this fibril, which is not to be confused with the coarser fibrils associated with connective-tissue and neuroglia cells. These fibrils are representative of axis cylinder processes.

Renal malignancies occur in childhood at any age and irrespective of sex. The vast majority are seen in the first five years of life and it has been

MALIGNANT TUMORS OF THE KIDNEY

reported repeatedly in the foetus. The youngest case in this series was five months and the oldest five and a half years. Either kidney is attacked with equal frequency and occasional bilateral instances have been reported, though the occurrence of bilateral tumors in the renal region is more commonly encountered in neuroblastoma of the adrenal.

Metastasis usually takes place by way of the blood-stream and implicates the lungs and the liver and rarely the opposite kidney or other organs. Dissemination occurs also by rupture of the tumor capsule and infiltration of the adjacent structures by tumor-cells. Secondary deposits are of the cellular type, the differentiated structures of the primary tumor being rarely found.

In childhood, symptoms of malignant disease of the kidney are generally absent. In contrast to the sequence of events in malignancy of the kidney

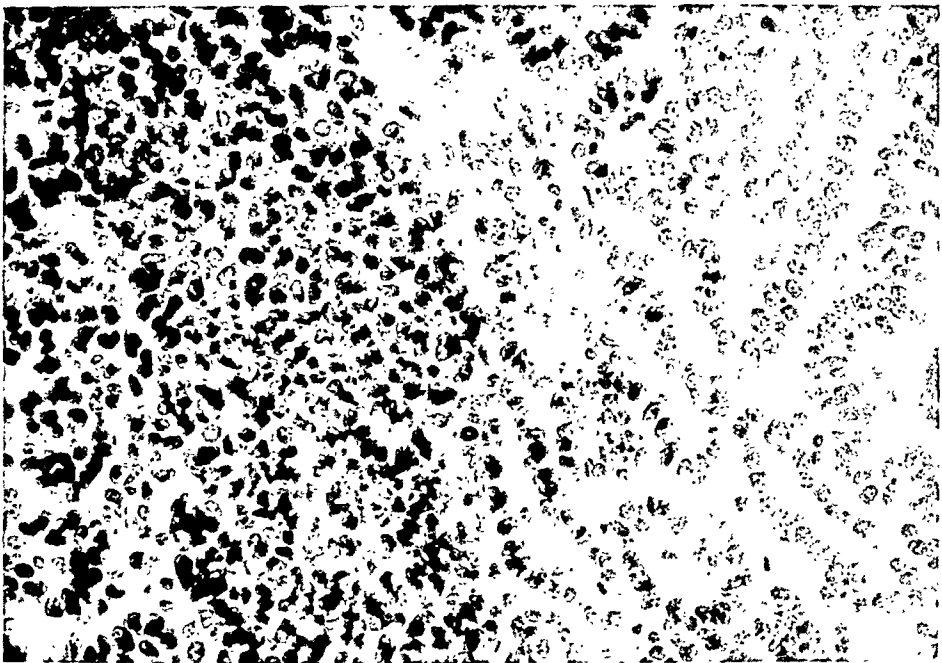


FIG. 3.—Low-power view showing abortive tubular structures and in the same field masses of tumor cells similar to those lining the tubular structures, growing in cords and clusters without lumina.

in the adult, where hæmaturia is often the initial symptom followed by pain and finally by tumor, the course of the disease in the child is silent, the danger signal of blood in the urine is practically never seen and the parents' concern is aroused at last only by the prominence of the infant's abdomen or the actual discovery of the mass. As the tumor progresses in size the child becomes irritable and evidences abdominal discomfort, but pain is rarely a salient feature. A secondary anæmia is usually present, constipation may develop from pressure of the mass and in the terminal stages there are dilatation of the superficial abdominal veins and rapid wasting. Nevertheless, it is remarkable in what good general condition a child may be with an enormous renal tumor.

It has been stated that trauma may be an etiological factor in renal neoplasms but no substantiation for such a statement can be found in our

series. In one instance, trauma initiated a severe attack of hæmaturia, but the growth was far advanced at the time of the injury.

The diagnosis is seldom in doubt as the progress of the growth is generally far advanced at the time of examination of the child. The tumor is usually solid, not tender, and smooth or somewhat nodular. Where marked irregularity of the tumor and fixation are present it is usually found that the neoplasm has broken through its capsule and enucleation is extremely difficult or impossible. At times the great proportions of the tumor render it immovable and yet the capsule is found to be intact and extension has not occurred. When rapidity of growth has caused central necrosis or there has been hæmorrhage into the tumor, a sense of fluctuation may be obtained.

As neoplasm enlarges it grows along the lines of least resistance; namely,

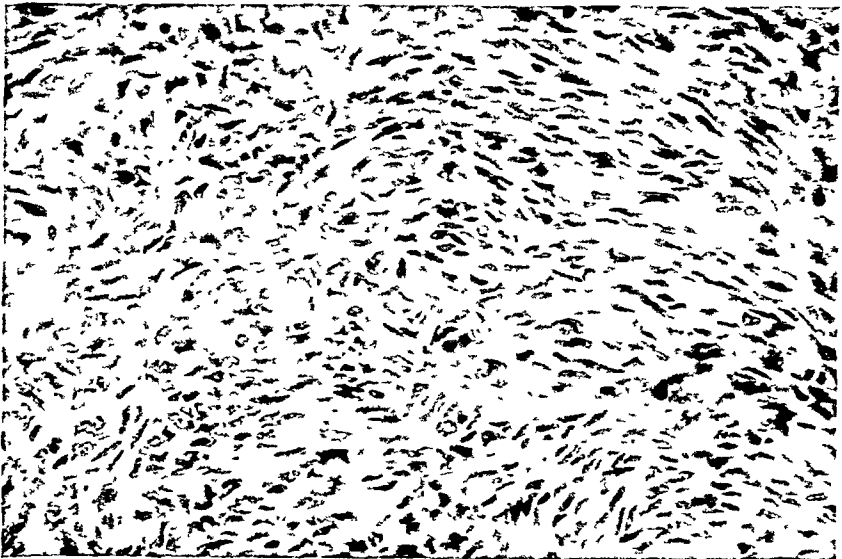


FIG. 4.

downward and anteriorly. At first the colon lies over its anterior surface and then gradually the peritoneal cavity with its contents is displaced toward the opposite kidney. The demonstration of mesial displacement of the colon by radiographical means is good evidence of the retroperitoneal character of the tumor.

In the differential diagnosis, other renal tumors, such as polycystic kidney, solitary cyst and hydronephrosis, should be borne in mind and splenic and hepatic enlargements excluded. The malignant tumor of the adrenal medulla is at times impossible of exclusion. Neuroblastoma of the adrenal occurs with less than one-fourth the frequency of embryoma and is generally characterized by the extensive metastases to the liver or to the flat bones of the skull, particularly of the orbit. Occasionally a case is encountered in which there is rapid local growth of the adrenal neoplasm with no gross evidence of metastasis and in which the silent clinical course and the position of the mass simulate the true kidney tumor.

MALIGNANT TUMORS OF THE KIDNEY

Pyelography is usually not necessary to establish the diagnosis, though occasionally in the early stage of the disease it may clarify a confused clinical picture, as occurred in one case in this series. The renal function test is of great importance as demonstrating an adequately functioning kidney on the involved side. In the large renal tumors of childhood the growth of the tumor occurs at the expense of the renal tissue and all that remains is usually a thinned-out, often functionless, strip of kidney with a fibrous zone of greater or lesser extent in contact with the tumor capsule. This intermediate zone represents renal parenchyma that has undergone fibrous degeneration from pressure of the mass. Encroachment of the tumor may obliterate the cavity of the renal pelvis and obstruct the ureter. As the neoplasm in rare instances is bilateral or may be sharply limited to one pole of the kidney, the demonstration of an adequate functional test does not necessarily prove the presence of an uninvolved kidney on the opposite side. However, the severity of a cystoscopic procedure in the very young patient, particularly the male, is attended by a definite risk and is unnecessary if one contemplates a transperitoneal nephrectomy, at which time the presence and normalcy of the other kidney can be readily proved.

Before proceeding to operation, evidence of metastasis should be ruled out by careful palpation of the liver and opposite kidney, and by X-ray examination of the chest. The size of the mass should be no contra-indication to exploration as it frequently occurs that a good plane of cleavage may be encountered and nephrectomy accomplished in the largest tumors. An outstanding example was in Abbé's case of an eight-months-old infant in whom a seven-and-a-half-pound tumor was enucleated. The kidney was not removed. This case was reported alive and well by Wollstein thirty-four years after operation.

During the period under discussion our percentage of nephrectomies has increased and the mortality has diminished. This has been attained by improved pre-operative and post-operative care and refinements of operative technic, particularly along the lines of hæmostasis, gentleness of manipulation and conservation of body heat. Probably the one factor of major importance in widening the scope of nephrectomy, has been the liberal use of transfusion both before and after operation. At the present time I believe that practically all cases should be explored except those in which metastasis or intraperitoneal extension can be demonstrated.

In the consideration of operative measures, three avenues of approach present themselves—the loin, the anterior extraperitoneal and the transperitoneal procedures. The advantages of the latter route are so marked in my opinion that a short discussion of the subject may not be amiss. The loin approach is used largely in European clinics but gives an inadequate approach to these very large tumors. Furthermore, exploration of the liver and the remaining kidney is denied and chromocystoscopy if not pyelography is demanded as a preliminary measure. The anterior extraperitoneal incision along the outer border of the rectus permits a more extensive operative field.

The peritoneum may be opened, the abdomen explored and the peritoneal incision sutured before proceeding to the enucleation of the tumor. The only advantage of this procedure over the transperitoneal route is a theoretical one—a lessened likelihood of implantation or dissemination of the neoplasm. This theoretical objection to the transperitoneal route, I believe, is not a valid one, as in three of the four cases alive and well at the present time, more than three years after operation, I used the transperitoneal approach. Certainly the advantages are preponderant, for in addition to abdominal exploration and adequate exposure, limited intraperitoneal extensions can be excised with the tumor.

Regarding anæsthetic, we have found that avertin used as a basal anæsthetic, 80 milligrams to the kilo. body weight, with a supplementary light

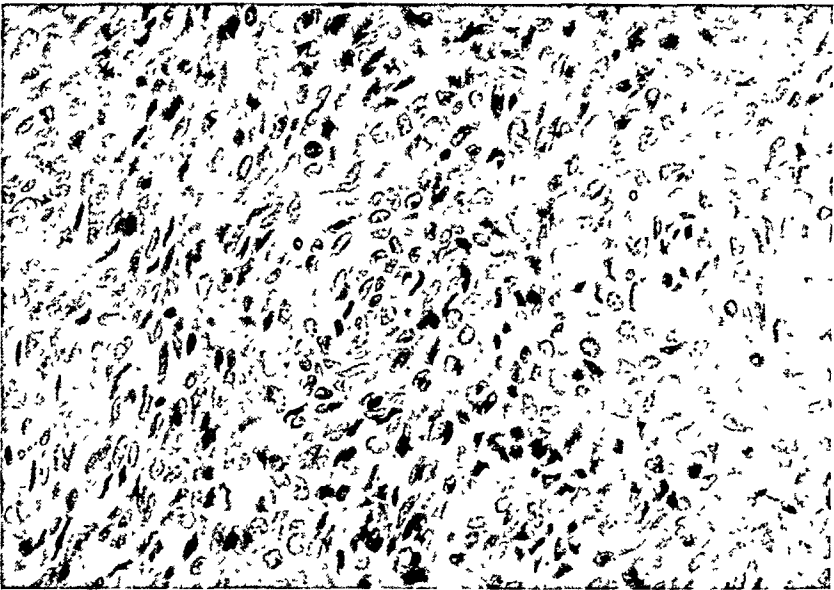


FIG. 5.

FIGS. 4 and 5.—Medium-power views showing more wildly growing, less differentiated tumor cells without any definite arrangement.

drop ether, is a most satisfactory method in this type of operation as in other procedures of magnitude on young children.

Robins, at the 1922 meeting of this society, reported his experience with four instances of renal neoplasm in childhood. One child, one year of age at the time of nephrectomy, was alive and well without evidence of recurrence twenty-two months after nephrectomy. The prognosis in a few recently reported series may be cited: Kretschmer and Hibbs, 1931, seventeen cases, a child of thirteen months well one and a half years after nephrectomy, for a mixed tumor. Hyman, 1930, seventeen cases, one boy of nine with hypernephroma, well ten years after nephrectomy. Wollstein, 1927, eighteen renal malignancies, two patients alive and well thirty-four years (Abbé's case) and six and three-quarters years respectively, after operation.

Local recurrence is prone to occur, a palpable mass being manifest within a few months and progressing with startling rapidity. One of the few

MALIGNANT TUMORS OF THE KIDNEY

exceptions to the usual behavior of recurrences was reported by Franks, where death did not occur until ten years after operation. Walker has stated that the average duration of the disease without operation was eight months, while in nephrectomized cases it was 16.8 months. Our experience, on the contrary, has been that in our cases recurrence has been noted in from three to six months and death almost invariably ensues in less than one year.

TABLE I
Embryoma of Kidney

Number of cases..... 30
Sex: male, 16; female, 14
Average age: two and one-half years
Side: right, 16; left, 14; bilateral, 0

Initial Symptom

Palpable tumor..... 17
Pain..... 8
Malaise and weakness..... 3
Hæmaturia..... 1
Digestive symptoms..... 1

Palpable mass in renal region present in every case.

TABLE II
Nephrectomized Cases without Evidence of Recurrence
Pathological Diagnosis—Embryomatous Mixed Tumor

	<i>Age at Op.</i>	<i>Sex</i>	<i>Side</i>	<i>Follow-up</i>	<i>Years since Op.</i>
(1)	11 mos.	Male	Left	By letter	12
(2)	2 7/12 yrs.	Female	Right	Examined	6 7/12
(3)	1 yr.	Female	Right	Examined	3 10/12
(4)	10 mos.	Male	Left	Examined	3 9/12

Total number of nephrectomies..... 22
Three-or-more-year cures..... 4—18.2%

(5)*	2 1/2 yrs.	Female	Left	Examined	2
------	------------	--------	------	----------	---

* Has increasing paralysis of lower extremities. Question spinal-cord tumor or poliomyelitis. No local recurrence. Possibility of metastasis to spinal cord cannot be ruled out, though it is considered unlikely.

TABLE III
Embryoma of Kidney—30 Cases

Nephrectomy.....	22	Biopsy.....	6
Operability.....	73.3%	Operative deaths.....	2
Operative deaths.....	4—18.2%	No operation (autopsy reports).....	2
Died from recurrence.....	11	Metastases: lungs.....	2
Alive with recurrence.....	1	Extension:	
No evident recurrence 3½ months.....	1	Adjacent lymph-nodes.....	4
Alive 2 years post-operative with possibly		Peritoneum.....	4
a metastasis to spinal cord.....	1	Intestine.....	1
No recurrence 3 years or more.....	4—18.2%	Renal vein.....	1

TABLE IV

Pathological Diagnosis Other Than Embryoma or Neuroblastoma

Number of cases: 7						
<i>Path. Diag.</i>	<i>Sex</i>	<i>Age</i>	<i>Side</i>	<i>Operation</i>	<i>Course</i>	<i>Late Death</i>
(1) Malignant tumor of epithelial origin	Male	6½ mos.	Right	Nephrectomy		2 mos. post-operative
(2) Small round-cell sarcoma	Female	3 yrs.	Left	Nephrectomy	Post-operative death	
(3) Small spindle-cell sarcoma	Male	4 2/12 yrs.	Left	Nephrectomy	Recovery	Recurrence 2 mos.
(4) Invading granuloma (?)	Female	19 mos.	Left	Nephrectomy	Recovery	Not traced
(5) Hypernephroma	Male	4 2/12 yrs.	Right	Nephrectomy	Post-operative death	
(6) Sarcoma	Male	3 yrs.	Left	Biopsy	Recovery	Death 5½ wks. after onset
(7) Fibrorhabdomyosarcoma (kidney anlage)	Female	4 yrs.	Right	None		Death 4½ wks. after onset

No pathological report available. Number of cases, 4.

TABLE V

Statistics for Total Group of 41 Renal Tumors

Cases deemed inoperable without exploration.....	3 cases
Exploration.....	10 cases
Nephrectomy.....	28 cases
Operability (41 cases).....	68.5%
Operative deaths.....	6 cases
Operative mortality.....	21.4%
Not traced, died or probably died from recurrence.....	15 cases
Living with recurrence eight months post-operative.....	1 case
Living without recurrence three and one-half months post-operative.....	1 case
Living with symptoms probably not due to recurrence.....	1 case
Alive and well three years or more after operation.....	4 cases
Two-year-or-more cures (4 or 5 cases).....	9.8%
	or
	12.2%

As a curative procedure, X-ray or radium radiation is of no avail. X-ray as a palliative measure is still used, though I feel that little benefit may be expected from its use.

From collected statistics the statement is made that the combined mortality from operation and late recurrence is between 86 per cent. and 93 per cent. The immediate operative mortality is from 24 per cent. to 40 per cent.

The statistical data derived from a study of this group of cases is given in the accompanying tables. The operative mortality for the whole group of nephrectomies was 21.4 per cent., while in the group classed pathologically as embryomatous mixed tumors it was 18.2 per cent. In the last eleven nephrectomies there has been but one operative death. The combined immediate and late mortality in the larger group was in the vicinity of 90 per cent. It is interesting to note that all surviving cases belong in the group of thirty definitely classified embryomas, there being four who have lived three years or longer without evidence of recurrence, a curative rate of 13.7 per cent. for

MALIGNANT TUMORS OF THE KIDNEY

the group or 18.2 per cent. of the twenty-two nephrectomized patients. A point of possible significance in the analysis of these few three-year cures is that the average age at the time of operation was sixteen months, in contrast to the average age of the embryomatous group as a whole, which was thirty months. Another point of interest is that, whereas the tumor in three of the cases was of the usual large size, the fourth three-year cure occurred in the patient from whom the smallest embryoma of the series was extirpated. In general, I believe the outlook for patients who have survived a two-year period without recurrence is better than in other types of malignancy, as recurrence and death so rapidly follow nephrectomy in the vast majority of renal neoplasms of childhood.

Grateful acknowledgment is due Dr. Sidney Farber, pathologist of the Children's Hospital, for the concise description of the pathology and the statement of the opinion we hold regarding the origin and classification of the renal tumors of childhood.

BIBLIOGRAPHY

- Albarran, and Imbert: *Les Tumeurs du Rein*. P. 414, Paris, 1903.
Beer, and Hyman: *Diseases of Urinary Tract in Childhood*. Paul Hoeber, Inc., N. Y., Chap. xiv, 1930.
Binney: *Cabot's Urology*, vol. ii, 1914.
Birch-Hirschfeld: *Zeigler's Beitr.*, vol. xxiv, p. 343, 1898.
Deming: *A. M. A.*, vol. lxxx, p. 902, 1923.
Dorderlein, and Birch-Hirschfeld: *Centralblatt f. d. Krkht. d. Haru-u. Sexnalorgane*, p. 88, 1894.
Ewing: *Neoplastic Diseases*. Second Edition, 1922.
Franks: Quoted by Warner.
Fraser: *Edinburgh Med. Jour.*, June, 1920.
Hasner: *Arch. of Path.*, vol. vi, p. 240, August, 1928.
Hedren: *Beitr. z. path. Anat. u. z. allg. Path.*, vol. xi, p. 1, 1907.
Hinman, and Kutzman: *ANNALS OF SURGERY*, vol. lxxx, p. 569, 1924.
Hyman: *Surg., Gynec., and Obst.*, vol. xli, p. 298, 1925.
Kretschmer, and Hibbs: *Surg., Gynec., and Obst.*, vol. lii, No. 1, p. 1, 1931.
Lieberthal: *Surg., Gynec., and Obst.*, vol. liii, No. 1, p. 77, 1931.
Loughnane: *Brit. Journ. Surg.*, vol. ii, p. 77, September, 1914.
McCarthy, and Magoun: *Surg., Gynec., and Obst.*, vol. xxxvi, p. 781, 1923.
Mixter: *ANNALS OF SURGERY*, vol. lxv, p. 628, 1917.
Robins: *ANNALS OF SURGERY*, vol. lxxvii, p. 306, 1923.
Sutton, Bland: *Tumors Innocent and Malignant*. Seventh Edition, p. 105, 1922.
Walker: *ANNALS OF SURGERY*, vol. xxvi, p. 528, 1897.
Warner, Hans: *Arch. f. klin. Chir.*, vol. cxlv, p. 347, March 31, 1927.
Watson, and Cunningham: *Lea and Febiger*, vol. ii, chap. xvi, Philadelphia, 1908.
Wilms: *Die Mischgeschwuelste*. Arthur Georgi, Leipzig, 1899.
Wollstein: *Arch. of Path. and Lab. Med.*, vol. iii, p. 1, January, 1927.

SARCOMA OF THE KIDNEY OF THE ADULT

A REVIEW OF TWENTY CASES WITH A REPORT OF A CASE *

BY E. STARR JUDD, M.D.

AND

JOSEPH M. DONALD, M.D.

FELLOW IN SURGERY OF THE MAYO FOUNDATION
OF ROCHESTER, MINN.

SINCE 1901 at The Mayo Clinic 570 operations (485 nephrectomies and 85 explorations) have been performed for malignant tumors of the kidney. In only twenty-eight cases was the tumor sarcoma. In 464 cases the diagnosis was of hypernephroma or carcinoma, in forty-three cases of epithelioma of the pelvis of the kidney, and in thirty-five cases of malignant tumor of the kidney; all the patients in the last group were children.

Of the entire series, only twenty tumors were proved microscopically to be sarcomas arising from the kidney. Retroperitoneal tumors which invaded the kidney or were closely associated with it were not included. Eight of the twenty cases were reported by Hunt and Hager,¹ in 1929. The history of a case observed recently will suffice to emphasize significant factors occurring in the course of the disease and its treatment.

A man, aged forty-six years, who came for consultation July 20, 1931, complained of pain in the upper left side of the abdomen of two months' duration. It was severe in onset and radiated to the left lumbar and left inguinal regions. The attack lasted about five days, and was followed by dull, constant pain, at times associated with nausea. He had not noticed hæmaturia and had not had any urinary symptoms.

The patient weighed 172 pounds. His weight had remained stationary. The systolic blood-pressure was 130 and the diastolic 90 in millimetres of mercury. A mass could be felt in the region of the left kidney. Urinalysis showed albumin graded II, a few granular casts, pus graded I, and no erythrocytes. The concentration of hæmoglobin was 93 per cent.; leucocytes numbered 8,300 in each cubic millimetre of blood. The Wassermann reaction of the blood was negative. A flat röntgenogram of the kidneys, ureters and bladder showed a large shadow in the region of the left kidney. Cystoscopic examination revealed a mass suggestive of a solitary cyst, although the presence of a neoplasm was considered probable. There was a marked ptosis of the right kidney, but this did not interfere with its function.

Left nephrectomy, performed July 27, 1931, revealed that a large tumor had almost destroyed the kidney (95 per cent.). The pathologists reported fibrosarcoma graded IV. It weighed 1,200 grams and measured fifteen by fourteen by thirteen centimetres. Giant cells were present. (Figs. 1, 2 and 3.)

Convalescence was uneventful and the patient was able to leave the hospital on the twenty-fifth day after operation. He was given a series of Röntgen-ray treatments before returning to his home. A letter received four months later stated that his health was good.

* Submitted for publication April 6, 1932.

SARCOMA OF THE KIDNEY

The sarcomas of the kidney of adult patients were equally divided among the sexes; ten patients were men and ten were women. The youngest patient was aged sixteen years and the oldest was sixty-eight years; the average age was forty-three years. The most common symptoms were pain, hæmaturia and loss of weight. In only five cases were there any symptoms referable to the bladder. Seventeen of the patients complained of pain; eleven stated that it was severe. The majority of the patients had noticed pain for less than a year. Sixteen had lost weight; the average loss was twenty-four pounds. In seven cases only hæmaturia had been observed and in six of these it had been present for less than a year. A palpable tumor was demonstrable in eighteen cases at the time of our examination. Six of the patients had detected the tumor before coming to the clinic. Some albuminuria was



FIG. 1.—Fibrosarcoma which has almost destroyed the kidney.

present in fourteen cases, pyuria in thirteen, and microscopical hæmaturia in seven. The studies of the blood did not reveal anything of significance. The concentration of hæmoglobin was estimated and averaged 66 per cent.

A positive diagnosis of renal tumor was made by cystoscopical examination in fifteen of the twenty cases. In one case the diagnosis was pyonephrosis. In another it was pyonephritis, which was thought to be sufficient to require surgical interference. In two of the cases cystoscopical examination was not done. In one case cystoscopical examination was carried out but failed to reveal the true condition.

Nephrectomy was performed in nineteen of these cases. In one case exploratory operation and biopsy were carried out. In eight of the twenty cases Röntgen-ray treatment was given post-operatively. The left kidney was the site of the lesion in eleven cases and the right kidney in nine.

Six of the tumors in the series were fibrosarcomas. Six were diagnosed as sarcoma and the character was not specified. One tumor was a round-celled sarcoma, one a mixed-celled sarcoma, one a myxosarcoma, one a fibro-myxosarcoma, one a liposarcoma, and three were spindle-celled sarcomas. One of the specimens contained fibrosarcoma, graded III, associated with adeno-carcinoma graded II in the same kidney. The specimen weighed 1,675 grams. Most of the twenty tumors were large; one weighed 2,700 grams. The average recorded weight was 1,262 grams and the average size was fifteen by fourteen by twelve centimetres. In only two cases was there any suggestion that the tumor might have arisen from the capsule of the kidney; the remainder apparently arose from the connective-tissue framework of the substance of the kidney.

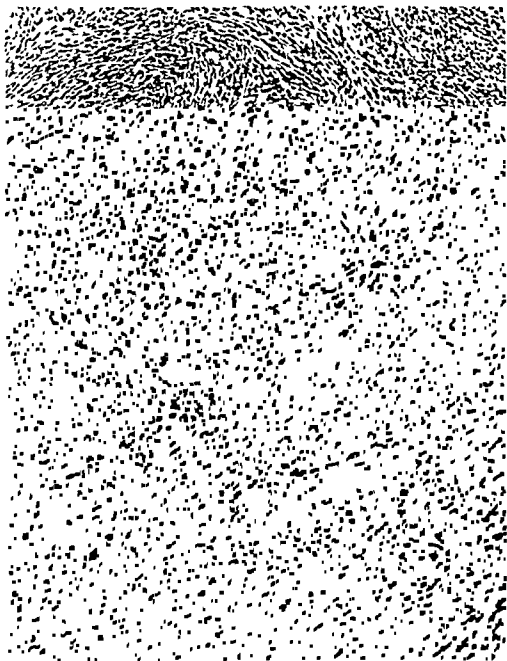


FIG. 2.—Character of fibrosarcoma is shown.

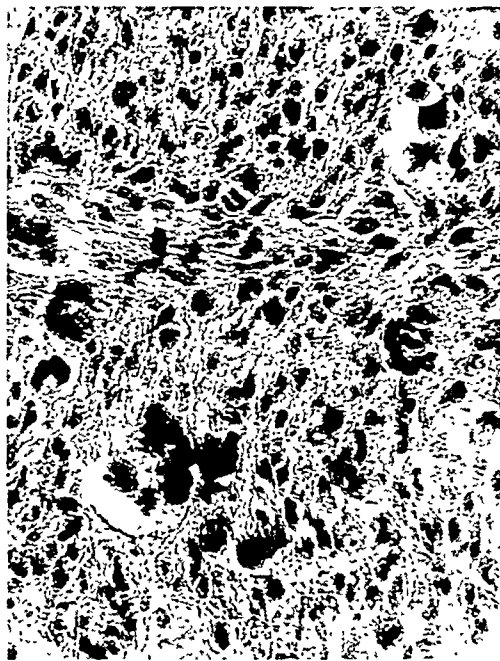


FIG. 3.—Character of cells, tumor giant cells and mitotic figures are shown.

The prognosis, in cases of sarcoma of the kidney, is very poor. Three of this series of patients died shortly after the operation. Most of the deaths occurred within the first year after operation. One patient lived eight years and then died, supposedly from pulmonary tuberculosis. Another patient was reported to have died from pneumonia one year after operation. One is living six years and three months after nephrectomy for fibrosarcoma graded II. In this case the surgeon recorded the fact that it was impossible to remove all of the malignant tissue. A series of Röntgen-ray treatments was given post-operatively. Recently the patient stated that he has gained thirty-five pounds. However, he reported the presence of a lump in the operative site, but it is not increasing in size. One patient is living two years and three months after nephrectomy and one is living four months.

SARCOMA OF THE KIDNEY

SUMMARY

Sarcoma of the kidney of the adult is comparatively rare; only twenty cases were observed in thirty years at the clinic. Apparently, the majority of these tumors arise from the supporting tissue of the substance of the kidney rather than from the capsule. Usually, the tumor is large and it can be palpated. Fibrosarcoma is the type most frequently seen. In our series, pain and loss of weight were the prominent symptoms. The ultimate prognosis in cases of sarcoma of the kidney is poor: only two patients of our group lived more than three years; most of them died within a year of the time they came for treatment. Nephrectomy followed by Röntgen-ray treatment seems to be the procedure of choice.

BIBLIOGRAPHY

- ¹Hunt, V. C., and Hager, B. H.: A Review of 271 Cases of Malignant Renal Neoplasms. Surg. Clin. N. Amer., vol. ix, pp. 149-159, February, 1929.

STANNOXYL IN THE TREATMENT OF CHRONIC RECURRING OSTEOMYELITIS

BY JACOB E. KLEIN, M.D.

OF CHICAGO, ILL.

FROM THE DEPARTMENT OF PEDIATRICS OF THE NORTHWESTERN UNIVERSITY MEDICAL SCHOOL

ONE of the most annoying and unsatisfactory conditions for the physician to treat is the residual chronic suppuration, associated with sequestrum and sinus formation, which are the usual sequelæ after an attack of acute osteomyelitis. These patients cannot be weaned from the hospital and dispensary and come back repeatedly for reoperations. At best the majority lead a life of semi-invalidism. If they have a persistent discharge from sinuses there is usually a marked secondary anæmia and not infrequently amyloidosis. At present the surgical methods leave much to be desired. The radical chiseling and gouging of the affected bones and widespread exposure of the affected areas do not permanently cure these cases. The maggot treatment which is becoming popular is intricate and involves more surgery. Under these conditions it should be highly desirable to have some chemo-therapeutic agent which may be taken orally and which is deposited in the reticulo-endothelium of the bone-marrow, where it might exert a bactericidal action. In this connection it is of practical interest to refer to the report of R. Gregoire and A. Frouin,¹ who, in 1917, carried out some valuable studies on the effect of tin-oxide and metallic tin on staphylococcic infections. They found that in the French province of Beauce the tin miners never suffer from furuncles, and that powdered tin is a popular remedy against this type of infection. These authors have studied the action of tin on the staphylococcus and on animals. They have shown that tin and its oxide are absorbed by the digestive tract, that it is quite harmless to the organism, and also that it has a therapeutic action in staphylococcic septicæmias. They successfully treated two cases of furunculosis, one case of chronic osteomyelitis, and one of compound fracture of the femur associated with suppuration by the administration of a mixture of tin-oxide and metallic tin (stannoxyll).

In a small series of five cases under my personal care the results have been so notable that I feel it desirable to report briefly the benefits which followed the oral administration of tin preparations in individuals suffering from chronic osteomyelitis.

CASE I.—F. K., at the age of twelve years, June 20, 1923, was admitted to the Michael Reese Hospital with symptoms of acute osteomyelitis in the left tibia. The tibia was opened and drainage established. The impression of the surgeon at the time was that the osteomyelitis was due to streptococcal infection of hematogenous origin. His condition was very serious and necessitated hospitalization for one year due to com-

¹ Gregoire, R., and Frouin, A.: *Action de L'Oxyde D'Etain et de L'Etain Metallique*. Bull. Acad. de. Med. Par., vol. lxxvii, p. 704, May 29, 1917.

STANNOXYL TREATMENT OSTEOMYELITIS

plications and reoperations. Since his discharge from the hospital in July, 1924, the patient has had acute exacerbations at times, which have necessitated re-hospitalization and reoperation, including seven sequestrectomies.

June 18, 1930, he again developed an area of acute inflammation in the upper third of the left tibia, a type of reaction which had previously required reoperation. He was given stannoxyl, two tablets four times daily by mouth. Within five days the inflammation had completely subsided. The patient has been completely well since then, is in good general condition and is well enough to participate in athletics.

CASE II.—S. S., admitted to Michael Reese Hospital in June, 1926, at the age of twelve years, with an acute osteomyelitis of the right femur. At operation drainage was instituted by wide exposure of the femur on its lateral aspect. After several months in the hospital he was discharged. December 6, 1928, he was readmitted with a recurrence in the same bone associated with fever, (102). At this time by operation the upper and lower sinuses were connected by making an extensive gutter in the

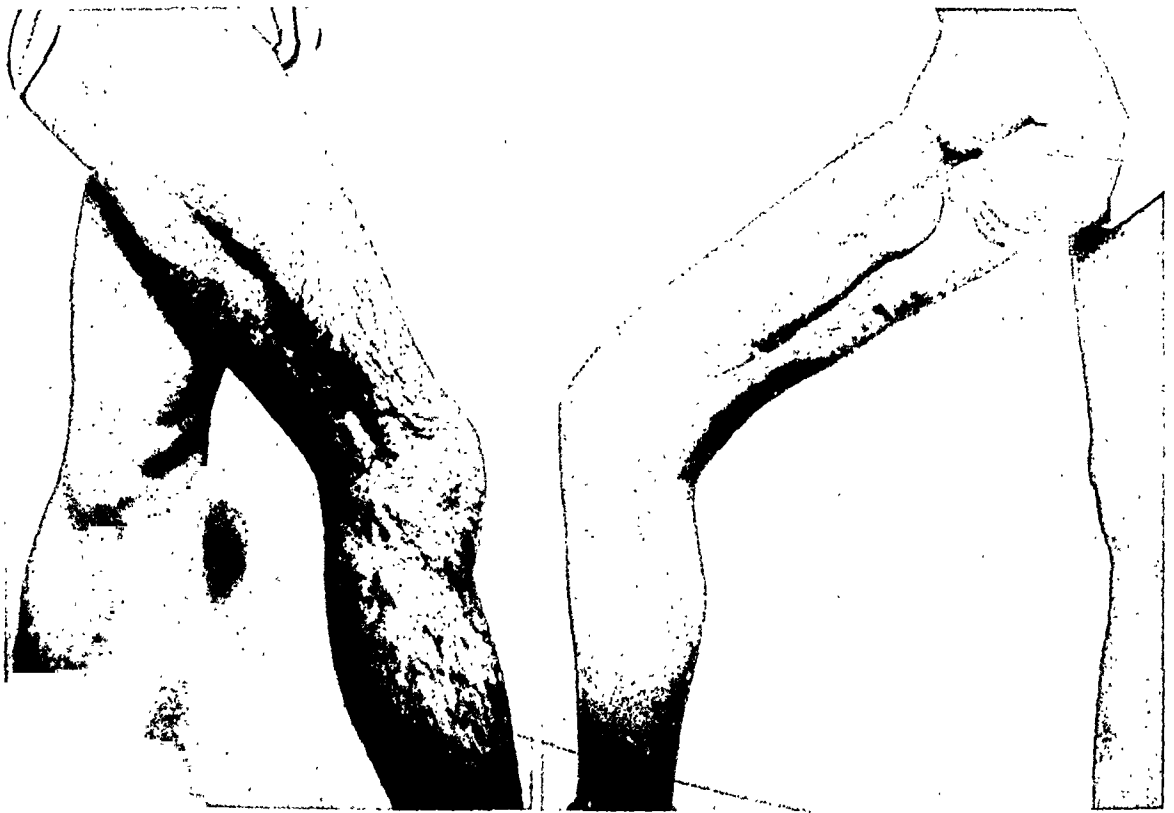


FIG. 1.

FIG. 2.

FIG. 1.—S. S., healed scar after stannoxyl treatment of osteomyelitis.
FIG. 2.—A. W., healed scar after treatment of chronic osteomyelitis with stannoxyl.

intervening femur. He was discharged March 26, 1929, with drainage still persisting from the wound. He was readmitted December 19, 1929, with another exacerbation. A sequestrectomy was performed. He was discharged January 9, 1930. Since then the patient has been visiting the dispensary where La Porte dressings have been applied. There has been a persistent discharge from one sinus for the past two years. The patient's condition was poor at this time, showing signs of secondary anæmia and a marked acne on the face.

February 7, 1932, the local applications were discontinued and oral treatment with stannoxyl was started. The dosage was two tablets every four hours. February 17 the patient stated that there was less discharge from the sinus and that he felt better. His weight at this time was 135 pounds. February 25 he reported a progressive diminution in the amount of discharge. March 2 the discharge had become sero-sanguinous; weight was 136 pounds. March 9—wound practically healed; slight scab over sinus;

weight 137 pounds. The facial acne has completely disappeared. April 7 weight 137½ pounds; no discharge; wound healed. (Fig. 1.) The patient volunteered the information that he felt better than at any time in his life; that he does not get tired as formerly.

CASE III.—A. W., male, aged nineteen years, was admitted to Michael Reese Hospital at the age of seven years with an acute osteomyelitis of the left femur. Up to February 24, 1931, he had been subjected to eight sequestrectomies. He was discharged with this note: That the osteomyelitis was still present and that he probably had amyloidosis. When I examined him February 10, 1932, he had five sinuses on the left thigh. There was an extensive operative scar over the lateral aspect of his left thigh and over the left hip. There was one large discharging sinus about four inches in extent at the lower end of the scar. There were three smaller discharging sinuses about the hip and one small sinus on the internal aspect of the thigh near the groin. The left thigh presented a flexion and abduction deformity at the hip of about 45°. The dressings showed a profuse, thick, greenish-yellow discharge.

February 10, 1932, he was given stannoxyl, two tablets every four hours. February 17 the wound looked better, although there was still the same amount of discharge. February 25, weight 140 pounds; less discharge. March 2 wound was much smaller; the three small sinuses about the hip were closed; weight 140½ pounds. March 9 large sinus down to one inch in width; weight 141½ pounds, feels better. March 23 discharge has sanguinous nature; wound smaller. March 30 wound smaller; still some discharge; weight 143 pounds. April 7 wound rapidly healing; weight 144 pounds. (Fig. 2.)

In the previous two cases it was noted that there was a marked improvement in the general condition as shown by the rapid gain in weight. In the former case a beneficial effect was also noted on the facial acne. There was a marked healing effect observed on the sinuses. When the healing process is advanced the drainage from the sinus assumes a sanguinous appearance.

CASE IV.—J. O., female, ten years old, was seen in consultation with Dr. J. Seilin, through whose courtesy this case record is presented. The patient had an acute osteomyelitis of the left femur. November 15, 1930, she was operated on and a typical osteomyelitis was found in the lower third of the femur, with stripping of the periosteum from the posterior surface of the femur at the linea aspera. She was discharged April 5, 1931, with some purulent drainage still present from the operation wound. May 5, 1931, X-ray examination showed the presence of three small residual bone abscesses in the lower end of the left femur. By May 10, 1931, the wound had closed completely. A tonsillectomy was done May 27, 1931. September 23, 1931, there was recurrence; the thigh sinus reopened; X-ray revealed a small cortical and periosteal abscess of the femur. At this time the patient was placed on the stannoxyl treatment, eight tablets daily. The sinus was completely closed by October 5, 1931, and there have been no recurrences since.

CASE V.—Mrs. P. M., aged sixty years, is reported through the courtesy of Dr. G. G. Herpe. She was seen February 1, 1931, when she was suffering from an arteriosclerotic gangrene of the fourth toe on the left foot. After attempts at local treatment it was found necessary to amputate the toe. The wound remained open and drained constantly, the adjacent part of the metatarsal bone having become necrotic. A sequestrum formed and a sinus developed with an opening on the sole of the foot. The sequestrum was removed, but the sinus continued draining. In March stannoxyl tablets were given, six daily. Within four weeks the discharge had ceased and the sinus had closed.

In this brief series there has been no doubt as to the marked therapeutic effect of tin and tin-oxide in chronic suppuration involving bone tissues.

To determine whether tin exerts a direct bactericidal effect on staphylococci

STANNOXYL TREATMENT OSTEOMYELITIS

I added tin-oxide and tin to several Petri dishes of agar. These plates were inoculated with *Staphylococcus aureus*; the staphylococci grew luxuriantly on this medium and showed no difference in amount or quality of growth from the control plates. Probably it exerts its therapeutic action through the reticulo-endothelial system, as is apparently the case with some other metallic drugs of great therapeutic value such as salvarsan and bismuth.

CONCLUSIONS

(1) Treatment of five cases indicates that tin-oxide and metallic tin exert a marked curative effect on chronic osteomyelitis with persistent sinuses and suppuration.

(2) The treatment is conservative, harmless and apparently effective.

(3) The effects in the limited number of cases reported are so positive that wider and more tests should be made and the results recorded.

NOTE.—Stannoxyd comes in 3 grain tablets of the following composition: metallic tin—42.5%; tin oxide—7.5%; amylum 37.5%; sucrose—12.5%.

POST-PYLORIC ULCER UNDER THE THERAPEUTIC MANAGEMENT OF INTERNIST, RADIOLOGIST AND SURGEON *

BY FREDERIC W. BANCROFT, M.D., AND CHARLES W. LESTER, M.D.
OF NEW YORK, N. Y.

FROM THE SURGICAL SERVICE OF THE FIFTH AVENUE HOSPITAL

THE combined efforts of the internist and surgeon have greatly reduced the morbidity and mortality in diabetes and toxic goitre. In contradistinction to this policy, it may be stated that in lesions of the duodenum the internist and surgeon have in general directed their energies in attempts to prove which could muster sufficient statistics to damn the end-results of the other.

Four years ago, at the beginning of my connection with the Fifth Avenue Hospital, Doctor Tenney, chief of the medical service, Doctor Cole, of radiology, and the surgical department decided we would attempt to see whether our combined efforts would improve the therapeutics of duodenal ulcer. It was decided that there should be no operation upon the ulcer unless two out of the three voted in favor of this procedure. The general precepts established in favor of operation were: first, failure of cure after adequate medical therapy; or, second, radiological evidence of the likelihood of perforation. In addition, the surgical department agreed that it would remove any possible foci of infection if this were recommended by the internist and radiologist. This in general means that tonsils, teeth or appendices would be removed without operative interference upon the ulcer. The medical department agreed that it would work in harmony with the surgical department—not only in the pre-operative preparation of the patient but also in the post-operative and post-hospital management. The radiological department, under the stimulus of Doctor Cole and Doctor Pound, has made a thorough study of the anatomy, physiology and motor phenomena of the gastro-intestinal tract in association with the patient's clinical manifestations. Therefore the advice and coöperation of this department are great aids in the general problem of therapy. While the question may be raised whether or not the radiologist should do more than describe the actual defects seen, it may be definitely stated that in our individual situation the therapeutic advice of the radiological department has been of great value. When an operation has been performed, the radiologist has attended the operation, scrubbed up, so that he could inspect the lesion and palpate it, and if a specimen were removed he has taken the specimen and by immediate injection maintained the contour as seen in the living body. He has studied the gross pathology of these lesions, as well as the microscopical. This department has also been very generous in the taking of follow-up films and in the duodenal operative series has

* Read before the New York Surgical Society, March 9, 1932.

personally seen the return post-operative cases in follow-up and has attempted to estimate from an impartial point of view the clinical results. In a combination where the surgeon and internist may take opposite views relative to therapy to be adopted the radiologist has often the deciding vote. He has the advantage of having seen the results of numerous methods of treatment in the hands of a wide number of physicians and surgeons, and he is an impartial observer in that he is not under obligation to either medical or surgical therapy.

As this report deals with the surgical phases of duodenal ulcer, no attempt has been made to evaluate the results of the purely medical therapy. This article deals mainly with: (a) The follow-up results in cases where the appendix has been removed in patients suffering from symptoms suggestive of post-pyloric ulcer, with radiological evidence of pylorospasm or ulcer associated with radiological evidence of pathology of the appendix or cæcum; (b) the analysis of the mortality and end-results of operation upon the stomach or duodenum for post-pyloric ulcer. The material for this analysis is taken from: (1) The cases referred to the surgical division by the medical department for appendectomy. (2) The post-pyloric cases upon which operation has been performed by the senior author. This latter plan has been adopted because a more careful analysis can be made of the pre-operative indications and the follow-up.

In cases of pylorospasm or duodenal ulcer the indications of radiological evidence of pathology of the appendix have been based on the following evidence: first, deformity of the cæcum; second, retention of barium for more than 120 hours in a fixed appendix; third, a local point of tenderness over the appendix when manipulated under fluoroscopical control; fourth, fixation or angulation of the appendix; fifth, fecoliths remaining coated with barium for over five days; sixth, non-filling of the appendix by both barium enema and meal by mouth is suggestive but not conclusive, as the appendix may have filled and emptied between the periods of examination, and here clinical evidence of localized tenderness must also be considered in making the diagnosis.

The surgical department has removed the appendix in twenty cases of pylorospasm and thirteen cases of ulcer, when requested by the medical department. Frequently operations have been performed on radiological evidence solely, where there was no subjective or objective signs of appendicitis. As the operative procedure has been the same in these two types, they will be discussed as a common entity except in their follow-up analysis. Usually the surgeon has told the patients in cases of ulcer that removal of the appendix was an attempt to remove the focus of infection or source of irritation and might be merely a first-stage procedure, and that later, if improvement were not sufficient, an operation on the ulcer might be advised. The incision used has been either the McBurney or the right rectus—and the Kammerer modification of the right rectus is preferred to the rectus-splitting, in that it gives better exposure of the intercostal nerves supplying the rectus muscle. In general, an attempt has been made to retract the nerves and not cut them.

It has been felt that as small an incision as is compatible with the exposure of the cæcum and terminal ileum is the procedure to be adopted. No attempt has been made to explore the region of the duodenum. It has been felt that palpation will miss an ulcer in a large percentage of cases and that visual exposure is necessary to be certain of a diagnosis. Visual inspection would necessitate a large incision, which would delay the convalescence of the patient and possibly interfere with a subsequent operative procedure. Pericæcal bands have been freed where they have been thought of sufficient moment to create symptoms, and in three cases where there has been marked fixation of the terminal ileum a free omental graft has been used for peritonealization. Follow-up on these three cases has been excellent. The appendix has been removed with a double inversion of the stump, and careful peritonealization. There has been no operative mortality.

Follow-up.—The analysis of the cases wherein the appendix has been removed has been classified as follows: (1) Good, where the patient may eat any type of food without any epigastric distress. (2) Fair, where the patient suffers occasional distress from dietary indiscretions. (3) Poor, where apparently the removal of the appendix has had no influence on the therapeutic treatment of the ulcer or pylorospasm. It may be stated that in the classification of the end-results it is difficult to evaluate an appendectomy. It is well known that there are long periods of remission in ulcer and also that many ulcers are cured by purely dietary measures. Recognizing these facts, we have tried, so far as possible, to classify the results as fairly as we can.

These cases have been followed for at least one year to rule out the possibility of early recurrence.

Appendectomy for Ulcer or Pylorospasm.—There have been eleven cases of ulcer for which appendectomy alone was done. Of these, two are lost in the follow-up. Of the others, five are good, two fair and two poor. Of the good cases all had definite pathology in the appendix as evidenced by kinks, adhesions and fecoliths; and all had extensive adhesions around cæcum and terminal ileum. Of the fair results both had kinked adherent appendices but there was little or no involvement of the cæcum and ileum. Of the poor results one had fecoliths in the appendix and the other had little or no abnormality. In the two lost cases the appendix did not show any abnormality at operation. If any deduction can be drawn from this small number of cases it might be said that the benefit of the operation is in direct proportion to the amount of abnormality in the appendix, cæcum, and terminal ileum.

There were two cases in which the X-ray or the operative findings indicated a healed ulcer. The results were good in both cases and in both cases adhesions between pylorus and gall-bladder had to be freed. In one there were also pericæcal adhesions and in the other there were adhesions binding the appendix.

There were twenty cases of pylorospasm as shown by X-ray. The results were: Good, eleven; fair, five; poor, none; not followed, four. Five of these had adhesions of terminal ileum and cæcum in addition to abnormality in

the appendix and the result was good in four and fair in one. All the others had some abnormality but limited to the appendix. The appendix is considered to be normal when it shows adhesions, kinks either from adhesions or short mesenterium, constrictions, or fecoliths. Little importance is attached to simple obliteration without some of the other abnormal features mentioned. Two cases in this group also had cholecystectomy performed. One case is lost and the other is rated as good.

	Total	Good	Fair	Poor	Not followed
Ulcers	11	5	2	2	2
Healed ulcers	2	2			
Pyloroplasty	20	11	5	0	4
Excluding lost cases					
Ulcers		64%	18%	18%	
Pyloroplasty		69%	31%		

Operations for Duodenal Ulcers.—With a system such as has been adopted at the Fifth Avenue Hospital, it is obvious that the number of cases coming to the surgeon will be relatively small. On the other hand, this series comprises cases that have had a long course of medical treatment and are medical failures. Follow-ups on these cases should not be compared with a medical series, which may include duodenitis, superficial ulcers and early penetrating ulcers.

In all, twenty-five consecutive cases are included in this report. Two of these patients had had a previous suture of a perforated ulcer, one case a previous cholecystostomy and one a previous cholecystectomy. There was no immediate operative mortality in this series. One death a year and a half post-operative is reported in the follow-up analysis.

Types of operations performed were: Gastroenterostomy, one case for healed ulcer, with marked pyloric obstruction. Judd pyloroplasty, three cases. Subtotal gastrectomy with a retrocolic Polya anastomosis, two cases. Subtotal gastrectomy with a Finney modification of Billroth II end-to-side gastroduodenostomy, two cases. Modified Devine operation of antral exclusion with Polya retrocolic gastrojejunostomy, seventeen cases.

The type of operation has been planned from the pre-operative study of the X-ray plates, the patient's symptoms, and the findings at operation. Where ulcer has appeared to be large and the deformity marked but where there has been what appeared to be a mobile duodenum resection has been done with the Finney modification of Billroth II. Where the evidence beforehand suggested that there was a small ulcer on the anterior surface, a Judd pyloroplasty has seemed to be the operation of choice. Gastroenterostomy has been used only once in this series. The majority of cases treated have been chronic, without retention, recurring after medical treatment, and therefore it was considered advisable to either resect the ulcer or exclude it from the food current. By far the greater number of cases have been operated on by the modification of the Devine method of pyloric exclusion. This

operation has seemed to combine the good points of the resection with a marked lessening of the operative risk. As the operation has been thoroughly described elsewhere, only a brief description will be given here.* The stomach is transected just proximal to the re-entrant angle. The mucous membrane is coned out of the antrum down to the pylorus and removed. The mucous membrane at the pylorus is inverted and sutured and the antrum is closed with several purse-string sutures. A retrocolic gastrojejunostomy of the Polya type is then performed with a very short jejunal loop. Anastomosis is so arranged that the proximal portion of the jejunum is sutured to the transection of the stomach beginning at the lesser curvature. The advantages of this procedure are that it leaves a very satisfactory closure of the pylorus, the ulcer is placed in an alkaline field at rest, there is not the danger of attempting excision of an ulcer adherent to the pancreas, and it is unnecessary to ligate the vessels of the lesser and greater curvatures save at the areas of transection.

In the cases operated on by the Devine method, there have been two post-operative complications of considerable moment, which were not attributable to the operation *per se*. One patient had a very stormy convalescence and was readmitted to the hospital a year and a half later with an upper jejunal obstruction. Jejunostomy was performed. She apparently recovered and returned home, but was readmitted about three weeks later with another intestinal obstruction. A lateral enteroenterostomy was performed, but she died of obstruction and peritonitis. Post-mortem examination revealed a hernia of the proximal loop of the jejunum just distal to the stoma into the lesser peritoneal sac through the gastrocolic omentum posterior to the anastomosis. In reviewing the history and post-operative follow-up films it seems evident that this herniation had occurred immediately post-operative. In this particular case the transverse mesocolon had been sutured to the anterior surface of the stomach but not to the posterior. It is needless to say that since that time care has been taken in suturing the mesocolon not only to the anterior but to the posterior surface of the stomach proximal to the stoma.

The second patient had gall-stones, as well as duodenal ulcer, and a simultaneous cholecystectomy was performed. He developed post-operatively a biliary fistula, ran a stormy post-operative course and subsequently a common-duct drainage was performed with a T-tube. He is still wearing the tube, is gaining weight and has no gastric disturbance, but there is still some evidence of common-duct obstruction.†

It is felt that the absence of mortality in twenty-five consecutive cases of operation for post-pyloric ulcer is attributable to careful pre-operative preparation, meticulous post-operative care and very close coöperation of the

* A modification of the Devine operation of pyloric exclusion for duodenal ulcer: American Journal of Surgery, May, 1932.

† Since the submission of this article the T tube has been removed, the patient has gained 25 pounds in weight, has no gastric disturbance and feels well.

POST-PYLORIC ULCER

CASE NUMBER	55181	54345	53467	51817	51659	51237	51191	50789	49829	45435	44134	41545	39919	36533	36106	33841	31269
DURATION OF SYMPTOMS	6 yrs	8 yrs	1 yr	8 yrs	4 yrs	8 yrs.	4 yrs	4 yrs	4 mo	7 yrs.	7 mo	5 yrs	1 yr	2 yrs	3 yrs	5 yrs	7 yrs.
DURATION OF MEDICAL TREATMENT	5 yrs <small>PREVIOUS OR CONCURRENT</small>	3 yrs	9 days	5 mo.	NONE	SPORADIC	NONE	1 1/2 yrs	4 mo	3 yrs	NONE	5 yrs	NONE	2 yrs.	NONE <small>TRACES OF PERFORATION</small>	5 yrs	NONE
DENTAL TREATMENT	PROPH.	EXTRACTION	PROPH AND EXTRACTION	PROPH	PROPH.	TEETH O.K.	TEETH O.K.	TEETH O.K.	PROPH	EXTRACTION AND PROPH	PROPH.	TEETH O.K.	TEETH O.K.	TEETH O.K.	PROPH	NONE	NONE
LENGTH OF PRE-OP TREATMENT	1 wk.	2 wks	5 wks	1/2 day	1 wk	1 1/2 days	2 days	5 days	2 days	4 days	3 days	2 days	3 days	3 days	5 days	9 days	5 days
PRE-OP DIET	SMITHIES	FLUID	SMITHIES	NONE	SMITHIES	SMITHIES	BLAND	SMITHIES	SMITHIES	GRUEL	HIGH CALORIC	SOFT		SMITHIES	REGULAR	SIPPY	SMITHIES
ANESTHETIC	AVERTIN ETHYLENE	AVERTIN ETHYLENE	AVERTIN ETHYLENE	ETHYLENE	ETHYLENE	N ₂ O AND ETHER	ETHYLENE	ETHYLENE	AVERTIN ETHYLENE	ETHYLENE	ETHYLENE	ETHYLENE	ETHYLENE AND ETHER	ETHYLENE AND ETHER	ETHYLENE	ETHYLENE	ETHYLENE
ASSOCIATED OPERATION	VENTRAL HERNIA APPENDIX	MECKEL'S DIVERTICULUM APPENDIX	GALL BLADDER	NONE	APPENDIX	GALL BLADDER	APPENDIX	NONE	APPENDIX	APPENDIX	APPENDIX	APPENDIX AND GALL BLADDER	APPENDIX	NONE	NONE	NONE	NONE
HYPODERMOCLYSIS	5	7	6-3	4	4	2	5	2	4	3	1	3-2	3	1	2	4	3
WOUND INFECTION	NONE	NONE	YES	HEMATOMA	NONE	NONE	NONE	NONE	APPENDIX WOUND	NONE	NONE	NONE	NONE	NONE	YES	NONE	NONE
COMPLICATIONS	NONE	NONE	PNEUMONIA BRONCHITIS AND GASTROINTESTINAL OBSTRUCTION	NONE	NONE	NONE	NONE	NONE	NONE	NONE	PNEUMONIA	INTESTINAL OBSTRUCTION AND ILEUS	NONE	NONE	NONE	NONE	BRONCHITIS
OUT OF BED <small>(no. days)</small>	12	13	1st OF 33 2nd OF 20	16	12	12	11	12	14	12	13	20	12	14	20	15	16
DISCHARGED <small>(no. days)</small>	17	20	104	20	16	14	13	15	17	15	16	23	15	19	22	18	19
IMMEDIATE RESULT	GOOD	GOOD	GOOD <small>POOR ULCER FAIR GASTRO AND GASTRO</small>	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD	FAIR	GOOD	GOOD	GOOD	GOOD	GOOD
LATE RESULT	GOOD 4 mo	GOOD 14 mo	GOOD 14 mo	GOOD 8 mo.	GOOD 2 mo.	GOOD 6 mo	GOOD 10 mo	GOOD 6 mo	GOOD 1 yr	GOOD 1 yr	GOOD 2 yr	DIED 2 yr. INTERSTITIAL OBSTRUCTION	FAIR 50 % RELIEVED	GOOD 3 yrs.	GOOD 3 mo LOST	GOOD 3 yrs	GOOD 4 yrs VENTRAL HERNIA

CHART I

medical department with the surgical department in the post-operative management. We believe that the Levin tube, inserted through the nares immediately post-operative, with instructions that the stomach shall be washed every two hours, is a life-saving measure. By this means old blood clot is removed, and gas distention and vomiting post-operatively are prevented.

Charts I and II show the details of pre-operative and post-operative treatment.

The medical department have made rounds on the post-operative patients daily, as they would on medical cases, and in several instances have instituted post-operative therapy, which has seemed to prevent mortality.

Follow-up.—In analyzing the follow-up results, the patient has been

	Pre-op.	Day of op.	1st day post-op.	2nd day post-op.	3rd day post-op.
FLUIDS BY MOUTH	Forced	None	Aq. 1 oz. q. $\frac{1}{2}$ h.	Aq. 1 oz. pep.mk. 1 oz. alternating q. 2 h.	Aq. 2 oz. pep.mk. 2 oz. alternating q. 2 h.
FLUIDS BY RECTUM	None	3 oz. q. 3 h.	3 oz. q. 3 h.	3 oz. q. 3 h.	3 oz. q. 3 h.
HYPODERMOCLYSIS	Once	Once	Twice	None	None
LAVAGE	Twice	q. 2 h.	q. 2 h.	None	None
ENEMAS AND COLON IRRIGATIONS	Enema twice	None	Colonic	Colonic	Colonic

CHART II

asked how soon he was able to return to his normal occupation, what dietary measures he is following, his personal habits relative to cigarette smoking and the use of tobacco, gain or loss of weight, and, finally, whether or not he would recommend this operative procedure to his closest friend or relative should he be suffering from a similar disease.

The gastroenterostomy case was followed for six months and then lost track of. At the end of six months his condition was excellent.

Of the three Judd cases two are excellent and one is poor, in that the patient still has symptoms of indigestion and pain if diet is not carefully followed.

In the four subtotal gastrectomies, one patient has been lost track of after three months, at which time he was well. The other three are classed as excellent.

Of the seventeen modified Devine operations two have not gone a sufficient time to judge sufficiently of the follow-up, though well when last seen.

POST-PYLORIC ULCER

One died at the end of a year and a half from intestinal obstruction. One is free from any gastric disturbance but is still wearing a T-tube in his common duct. Of the remaining thirteen cases, eleven are on non-restricted diets and feel well, while two have some gas or indigestion if they are careless of their diet. All thirteen, when questioned, said they would recommend the operation to their nearest friends or would have it done over again under similar circumstances.

CONCLUSIONS

First, we believe that a close therapeutic agreement between the radiological, medical and surgical departments has been of benefit to the patient suffering from post-pyloric ulcer.

Second, where an appendectomy for pylorospasm has been performed upon the recommendation of the medical and radiological departments, results have been satisfactory.

Third, where appendectomy has been performed for the removal of a focus of infection or a source of irritability, upon the recommendation of the medical and radiological departments, there has been an 82 per cent. benefit and an 18 per cent. failure in the cases analyzed.

Fourth, we believe that the mortality and morbidity of the patients operated upon for post-pyloric ulcer have been definitely reduced by the coöperation of the above-named departments.

THE LENGTH AND POSITION OF THE VERMIFORM APPENDIX*

A STUDY OF 4,680 SPECIMENS
BY DONALD C. COLLINS, M.D.

FELLOW IN PATHOLOGY,
OF ROCHESTER, MINN.

FROM THE DEPARTMENT OF PATHOLOGY OF THE MAYO FOUNDATION

THE length of the appendix as noted in the literature from 1861 to the present time is given in Table I. Byron Robinson,²⁶ in 1895, stated that the appendix of the male is, on an average, 0.6 centimetre longer than that of the female. Fawcett and Blachford,⁷ in 1900, studied 350 anatomic dissections and concluded that the appendix of the male is, on an average, 1 centimetre longer than that of the female; this was substantiated by Nowicki,²¹ in 1909. Dock,⁶ in 1892, stated that in his experience appendices

TABLE I
Length of the Appendix as Given by Various Authors

Year	Author	Shortest, Centimetres	Longest, Centimetres	Average Length, Centimetres	Average Diameter, Centimetres
1861	Luschka		23.0		
1888	Ranschoff		19.0		
1890	Grauer (Kelly and Hurdon)		33.0		
1891	Ferguson	2.2		10.13	0.8
1892	Clado			8.0	
1893	Ribbert			8.3	
1893	Lafforgue		24.0		
1893	Bryant	0.6		8.25 at age of 60	
1895	Berry	3.1	13.3	8.3	0.6 at base 0.5 at tip
1900	Fawcett and Blachford			8.4	
1900	Lenzmann		22.0		
1903	Huntington	0.5			
1904	Holmes			6-10	-1.0
1905	Kelly and Hurdon			9-10	0.6
1905	Weaver (Kelly and Hurdon)		21.5		
1905	Blake (Kelly and Hurdon) . .		24.0		
1909	Nowicki			8.4	0.7
1913	Deaver	1.0	23.0	8-9	0.3-0.5
1918	Lewis	2.0	20.0	8.3	
1920	Lake		29.4		
1923	Arthur Robinson	1.8	23.0	9.2	0.6
1923	Piersol	1.0	24.0	8.4	
1924	Davis			8.75-10	0.6
1927	Royster	2.5	29.4	7.5	
1929	Henke and Lubarsch		28.0	9.5 at age of 20-30	

* Submitted for publication June 30, 1931.

POSITION AND LENGTH OF APPENDIX

normally are longer in the Negro race than those found among his white patients. The longest appendix on record in the literature was one reported by Grauer,¹⁰ in 1890. This specimen was 33 centimetres long, after being fixed in solution of formaldehyde. The next longest specimen was one reported by Lake,¹⁶ in 1920; it was 29.4 centimetres long and was obtained from a Negro aged twenty-two years, who had had symptoms referable to the lower part of the abdomen during the previous year, and had suffered sudden acute exacerbation of chronic appendicitis with perforation of the tip. The next longest appendix was reported by Henke and Lubarsch,¹¹ in 1929, it was 28 centimetres long and was found at necropsy of a man aged forty years who had died of a disease unrelated to the appendix.

The length of the appendixes in my series which represents 4,680 specimens removed from post-mortem material are given in Table II. It may be noted that approximately 61 per cent. of specimens were between 6 and 9 centimetres long. The extremes of length were 0.3 and 24.5 centimetres; the average length was 8.21+ centimetres. The average length of the appendixes of the male was 0.68+ centimetre longer than that of the female. One full-term, normally developed fetus (stillborn) was reported as not having an appendix.

TABLE II

Length of the Appendix in 4,680 Specimens

Length, Centimetres	Specimens	Per Cent.	Length, Centimetres	Specimens	Per Cent.
1.....	12	0.26	12.....	174	3.72
2.....	44	0.94	13.....	122	2.60
3.....	89	1.90	14.....	100	2.14
4.....	214	4.57	15.....	75	1.60
5.....	322	6.88	16.....	36	0.79
6.....	482	10.30	17.....	20	0.43
7.....	733	15.66	18.....	11	0.23
8.....	864	18.46	19.....	6	0.13
9.....	783	16.72	20.....	1	0.02
10.....	358	7.65	24.5.....	1	0.02
11.....	233	4.98	Totals.....	4,680	100.00

The longest appendix in my series was observed in a man aged seventy-six years, whose weight was 122 pounds (55 kilograms) and whose height was 177 centimetres. He died of a disease entirely unrelated to the appendix and, so far as could be learned from relatives, he had never had abdominal pain which might be construed as being referable to the appendix. The retrocecal position of this appendix and the intimate adhesion to the posterior wall of the cæcum is shown in Fig. 1. Its length after being fixed in formalin was 24.5 centimetres; its tip reached to the hepatic flexure of the colon.

The first comprehensive study made of the position of the appendix was completed by Gladstone and Wakeley,⁹ in 1924, who studied 3,000 anatomic dissections. Previous to this, other authors had stated their belief, from observations at necropsy or operation, that the majority of appendixes are situated anteriorly, that they are free and hang over the brim of the pelvis.

Gladstone and Wakeley concluded that 0.9 per cent. were anterior or pre-ileac, 0.5 per cent. were splenic or post-ileac, 27.5 per cent. were pelvic, lying on the psoas major muscle near or hanging over the brim of the pelvis, 1.86 per cent. were subcecal and beneath the caput ceci, 69.2 per cent. were post-cecal and retrocolic, and 0.033 per cent. (one case) were ectopic. The position of the appendix in this series is shown in Table III. Three thousand six hundred seventy-six specimens (78.5 per cent.) were situated anteriorly, and 1,004 (21.4 per cent.) were retrocecal. These observations agree substantially with statements made by other observers.^{1, 4, 5, 11, 14, 18, 21, 24, 25, 27}



FIG. 1.—Posterior aspect of regions of the ileocecal and ascending colon. The appendix was 24.5 centimetres long when fixed in solution of formaldehyde and extended to the hepatic flexure of the colon. It was intimately adherent to the posterior surface of the cæcum and ascending colon; its lumen was obliterated.

I believe that the only true retrocecal appendix is one that is either partially or entirely retroperitoneal and adherent to the posterior wall of the cæcum.

SUMMARY

A pathologic anatomic study is presented in which are summarized the length and position of 4,680 appendixes derived from post-mortem material. Seventy-eight and five-tenths per cent. of the appendixes were situated anteriorly and 21.4 per cent. were retrocecal. Approximately 61 per cent. were between 6 and 9 centimetres long. The appendixes of males averaged 0.68 centimetre longer than those of the females. The average length of all the appendixes was 8.2 centimetres. An unusually long appendix, 24.5 centimetres, was noted. In 50.8 per cent. of the cases, appendectomy had been performed.

TABLE III

Position	<i>Position of Appendix in 4,680 Specimens</i>	
	Specimens	Per Cent.
Anterior		
Free.....	3,262	69.68
Bound down in pelvis.....	370	7.90
Adherent to mesentery of terminal portion of ileum	44	0.94
Total.....	3,676	78.52

POSITION AND LENGTH OF APPENDIX

TABLE III—(Continued)

Position	Specimens	Per Cent.
Retrocecal		
Bound down and either partially or totally retroperitoneal	913	19.50
Free and subcecal	58	1.24
Bound down to retroperitoneal tissue behind terminal portion of ileum	33	0.71
Total	1,004	21.45

BIBLIOGRAPHY

- ¹ Berry, R. J. A.: The Anatomy of the Vermiform Appendix. *Anat. Anz.*, vol. x, pp. 761-769, July 19, 1895.
- ² Bryant, J. D.: The Relations of the Gross Anatomy of the Vermiform Appendix to Some Features of the Clinical History of Appendicitis. *ANNALS OF SURGERY*, vol. xvii, pp. 164-180, 1893.
- ³ Clado, M.: Appendice cæcal: anatomic, embryologie, anatomie comparée, bactériologie normale et pathologique. *Compt. rend. Soc. de biol.*, vol. xlv, pp. 133-172, February, 1892.
- ⁴ Davis, G. G.: Applied Anatomy. Sixth Edition, J. B. Lippincott Company, 416 pp., Philadelphia, 1924.
- ⁵ Deaver, J. B.: Appendicitis. Fourth Edition, P. Blakiston's Son and Co., p. 43, Philadelphia, 1913.
- ⁶ Dock, G.: Notes on the Appendix Vermiformis: Anatomical and Clinical. *Med. Age*, vol. x, pp. 397-402, 1892.
- ⁷ Fawcett, E., and Blachford, J. V.: The Length of the Appendix. *Jour. Anat. and Physiol.*, Append., vol. xxxiv, pp. xx-xxiv, February, 1900.
- ⁸ Ferguson, John: Some Important Points Regarding the Appendix Vermiformis. *Am. Jour. Med. Sc.*, vol. ci, pp. 61-62, January, 1891.
- ⁹ Gladstone, R. J., and Wakeley, C. P. G.: The Relative Frequency of the Various Positions of the Vermiform Appendix: as Ascertained by an Analysis of 3,000 Cases: with an Account of Its Development. *Brit. Jour. Surg.*, vol. xi, pp. 503-520, January, 1924.
- ¹⁰ Grauer, F.: Quoted by Kelly and Hurdon.¹⁴
- ¹¹ Henke, Friedrich, and Lubarsch, Otto: Handbuch der speziellen pathologischen Anatomie und Histologie. Julius Springer, vol. iv, pt. 3, pp. 490-491, Berlin, 1929.
- ¹² Holmes, Bayard: Appendicitis. D. Appleton and Co., p. 18, New York, 1904.
- ¹³ Huntington, G. S.: The Anatomy of the Human Peritoneum and Abdominal Cavity. Lea Brothers and Co., 292 pp., Philadelphia, 1903.
- ¹⁴ Kelly, H. A., and Hurdon, E.: The Vermiform Appendix and Its Diseases. W. B. Saunders and Co., pp. 135-139, Philadelphia, 1905.
- ¹⁵ Lafforgue, Evariste: Recherches anatomiques sur l'appendice vermiculaire du caecum. *Internat. Monatschr. f. Anat. u. Phys.*, vol. x, pp. 141-167, 1893.
- ¹⁶ Lake, G. B.: Report of an Extremely Long Vermiform Appendix. *Jour. Am. Med. Assn.*, vol. lxxv, p. 1269, November 6, 1920.
- ¹⁷ Lenzmann: Ueber die entzündlichen Erkrankungen des Darms in der Regio ileo-coecalis und ihre Folgen. *München med. Wchnschr.*, vol. xlvii, pp. 1753-1756, December, 1900.
- ¹⁸ Lewis, W. H.: In: Gray, Henry: Anatomy of the Human Body. Twentieth Edition, Lea and Febiger, pp. 1178-1179, Philadelphia, 1918.
- ¹⁹ Luschka: Ueber die peritoneal Umhüllung des Blinddarmes und über die Fossa ileo-coecalis. *Virchow's Arch. f. path. Anat. u. Physiol.*, vol. xxi, pp. 285-288, 1861.
- ²⁰ Monks, G. H., and Blake, J. B.: The Normal Appendix: Its Length, Its Mesentery, and Its Position or Direction as Observed in Six Hundred and Fifty-six Autopsies. *Boston Med. and Surg. Jour.*, vol. cxlvii, pp. 581-583, November 20, 1902.

- ²¹ Nowicki, W.: Anatomische Untersuchungen über Appendix und Appendizitis. Virchow's Arch. f. path. Anat. u. Physiol., vol. cxcv, pp. 175-227, January-February, 1909.
- ²² Piersol, G. A.: Human Anatomy. J. B. Lippincott Co., pp. 1664-1665, Philadelphia, 1923.
- ²³ Ranschoff, Joseph: Considerations on the Anatomy, Physiology and Pathology of the Cæcum and Appendix. Jour. Am. Med. Assn., vol. xi, pp. 40-46, July, 1888.
- ²⁴ Ribbert, H.: Beiträge zur normalen und pathologischen Anatomie des Wurmfortsatzes. Virchow's Arch. f. path. Anat. u. Physiol., vol. cxxxii, pp. 66-90, April, 1893.
- ²⁵ Robinson, Arthur: In: Cunningham's Text-book of Anatomy. Fifth Edition, William Wood and Co., p. 1206, Edinburgh, 1923.
- ²⁶ Robinson, Byron: The Appendix and Cæcum in One Hundred and Twenty-eight Post-mortems with a New Theory as to the Cause of Appendicitis. Med. Rec., vol. xlviii, pp. 757-762, November 30, 1895.
- ²⁷ Royster, H. A.: Appendicitis. D. Appleton and Co., p. 12, New York, 1927.

SURGICAL POSSIBILITIES IN THE TREATMENT OF ANTERIOR POLIOMYELITIS *

BY ARMITAGE WHITMAN, M.D.

OF NEW YORK, N. Y.

IN NO branch of orthopædic surgery are the recent developments in that specialty more spectacular than in the surgical treatment of chronic anterior poliomyelitis. To the average physician and surgeon infantile paralysis means helplessness, plaster-of-Paris and braces. To the average layman the picture is one of even more bitter despair. To the average charlatan it is a golden field with limitless possibilities of exploitation. Much confusion apparently exists not only in the lay but in the professional mind as to what may be expected from treatment, when it should be begun, and of what it should consist.

From the ideal standpoint the orthopædic treatment of poliomyelitis should begin the moment the diagnosis of the disease is made, and continue throughout the patient's lifetime. Practically, it usually begins when the acute symptoms have subsided and continues until the patient and surgeon are convinced that no further improvement is possible. The aims of orthopædic treatment are three: (1) The prevention of deformity; (2) the maintenance of muscular tone; (3) the maximum utilization of remaining muscular power by muscle transplantation and skeletal stabilization.

As to the pathology of the disease, it is an inflammation centering in and about the anterior horn cells of the spinal cord, and either by hæmorrhage into the cells or pressure about them depriving them of their function. The muscles whose efferent nerve impulses are transmitted through those cells suffer a flaccid paralysis. Fortunately, a majority of the cells lose their function from pressure rather than from actual destruction. Thus, as the inflammation subsides, power gradually returns to the secondarily affected muscles. If, however, during that period deformity had been allowed to develop, no degree of returning nerve power could restore normal muscle function.

Somewhat arbitrarily we have divided the disease into three phases—(1) Acute, (2) convalescent, and (3) chronic, and each phase has its different treatment.

The orthopædic treatment during the acute stage consists in the prevention of deformity, and, if I may use such a phrase, the immobilization of the affected area. The idea of being able to immobilize a segment of the spinal cord may seem fantastic. If we place the affected limbs in plaster-of-Paris we have assured ourselves that at least as few impulses as possible pass through, and by their passage irritate, the inflamed area. The same principle was applied by Hugh Owen Thomas to the treatment of peritonitis, and I

* Read before the New York Academy of Medicine, December 11, 1931.

have no doubt that it was handed on by him to Sir Robert Jones. Unless I am much mistaken, it is the only treatment that Sir Robert uses. It should undoubtedly be insisted upon until all muscular tenderness has disappeared. I think we all agree that muscular tenderness may be interpreted as a sign that the inflammation in the cord has not subsided. One of the strongest impressions left in my mind by the epidemic of 1916 was that the worst cases, and those in which the tenderness persisted longest, were those in which active treatment had been instituted too early.

When the acute stage has passed, we encounter from the therapeutic standpoint the most perplexing period of the disease. Most orthopædic surgeons have agreed to set two years as the period of potential recovery, and feel that, except for correction of deformity, no operative treatment should be undertaken during that period. During that two-year period the first essential is the prevention of deformity.

Deformity may occur (1) By the force of gravity; (2) by unopposed action of active muscles; (3) by habitual posture; (4) by functional use. The commonest example of the first is toe drop, caused by the attitude as the patient lies in bed, plus the weight of the bedclothes. Flexion deformity at the hip occurs by the unopposed action of the tensor fasciæ femoris muscle, which, curiously enough, is almost never completely paralyzed. Habitual posture, as when a completely paralyzed person sits about, is in itself sufficient to cause flexion contractions at the hips and knees. Functional use as a cause of deformity may be seen when a patient with weakened back or abdominal muscles sits up unsupported, and develops curvature of the spine. All these factors must constantly be kept in mind, and deformities thus prevented rather than cured. I am confident that the profession at large has learned many of these lessons, for since the war I have seen nothing to compare with the horrible deformities that I saw throughout the State in the epidemic of 1916.

The form of apparatus that is used will naturally vary according to the training and taste of a particular surgeon, but the end of all of them is the same, prevention of deformity and protection against gravity.

One of the most vexing questions is that of when to allow the patients up. There is no doubt that overfatigue of a weakened muscle is the greatest obstacle to its recovery. On this theory Doctor Lovett was accustomed to keep the patients off their feet indefinitely, while they had massage and muscle training. I feel myself, however, that the mental attitude of the patient is of the utmost importance, and that the depressing effect of such prolonged inactivity upon the patient must outweigh its benefit to a given muscle. Provided the affected muscles are properly protected, I cannot see that a small amount of exercise can be harmful. Even when accomplished only with the aid of braces and crutches the power of independent locomotion is of tremendous psychological value to the patient.

We have now arrived at the controversial phase of the disease. What is to be done during the two-year period that we have agreed to regard as that of potential recovery? Shall the patient have massage, muscle training, water-

borne exercises in a pool; various forms of electricity, chiropractic or osteopathy? I think the best thing to do is to fall back upon pathology. I take it for granted that a detailed muscular examination of the patient has been made. As the result of such an examination we know that certain muscles are completely, others partly, paralyzed. We can by no means thus far devised affect the diseased area in the cord, except by the itch of ill-advised activity to prolong its inflammation.

We have protected the remaining muscles by appropriate apparatus against the harmful effects of deformity and overfatigue. We know that paralyzed muscles when completely neglected atrophy, become stiff, and lose their tone, and that when a bone no longer functions in weight bearing it loses its calcium. Obviously, therefore, the muscles must be kept in the best of condition against the possible return of nerve power. Anything, therefore, that preserves their blood supply and is not so violent as to cause harm is beneficial.

Although no man by taking thought can add a cubit to his stature, we know that by taking appropriate exercises we can increase the size of a muscle. Suppose that half one's biceps muscle were paralyzed, one might by careful, persistent training build it up until the remaining half could do the work of the whole. Muscle training, under-water exercises and electricity all seek this end. The voluntary exercises, in which the patient's own brain is the activating force, are of far more value than the passive.

Water-borne exercises are certainly the most logical form of treatment. There is a bathtub in practically every home. This may be filled with water at from 85° to 90°, a little salt put in the water to increase its buoyancy, and the child placed in the tub and allowed spontaneously to move his limbs. If the doctor will then observe him carefully, he can, without particularly expert knowledge on his part, devise exercises for the affected muscles.

In the early stages of the disease electricity is dangerous. The only form of electricity that has been proved of any value is a form of current, such as the Bristow coil, which actually produces muscular contraction. Unless in the hands of a real expert, who knows how to stimulate one affected muscle at a time, there is great likelihood that all the muscles of an extremity will be stimulated at once, thereby cultivating the strong at the expense of the weak. Even an expert is apt to be carried away, and contract a muscle twenty times or more, when four or five contractions would be all that were indicated. The greatest of all dangers to a convalescent muscle is overfatigue from any cause. If there must be a choice between the two evils, too much treatment is far more harmful than no treatment whatever.

The attention of the profession in general should be called to two facts:— That the patient must not be sacrificed to his disease, and that the family must not be sacrificed to the patient. A patient is not likely to be greatly soothed by exercise in the relaxing luxury of a pool if it takes him two hours in a crowded bus to get to the hospital, and two more to get home again. Also, the paralyzed patient is but one unit in a family and sacrificing all the family resources to send him to a certain specialist, or away from home, perhaps, for a given form of treatment is mistaken kindness, and does most

harm to the recipient himself. From the very beginning emphasis must be placed upon making the patient independent, and not dependent upon the ministrations of his family or friends.

We now come to the third stage of the disease. We assume that every legitimate form of treatment has been tried, that a certain amount of improvement has been gained, but that it is agreed by all, including the patient, that he has come to a standstill.

If possible, before coming to this conclusion, he should have tried every form of treatment, excepting the positively harmful *quack* remedies, at his command. There is a tremendous psychological element in this, as in all diseases. Some patients are reluctant to face the truth, and drag themselves about from clinic to springs, and from springs to Europe for year after year. Others, more tough-minded, prefer to face the truth early. The sooner a given situation is faced, and the necessary adjustment made to it, the better it is for all concerned. I am strengthened in this belief by my experiences as Consulting Surgeon to the Veterans' Bureau. I think it is scarcely an exaggeration to say that the only veterans who have made a satisfactory adjustment to their situation are those who have suffered amputations. They recognize that their disability is final. The reaction that takes place is ably described by Lawrence Stallings in his account of his personal experience in his book, "Plumes."

In this connection, however, I must emphasize the great distinction that must always be kept in mind between treatment of paralysis of muscles of the upper and the lower extremity. The function of the lower extremities is to support the weight of the body, and any muscle to be an efficient aid to locomotion must very nearly approximate its normal strength. After various operations on the foot, for example, we frequently see return of power to the muscles of the toes. This gives the patient the greatest encouragement, but from a practical standpoint is of no use whatever. Indeed, it may be harmful, as such muscles may, being unopposed, have just enough power to produce deformity. In the upper extremity, however, the situation is quite different, as the slightest degree of power in the fingers or thumb may make a useless into a useful hand.

The principles of operative treatment are to make effective use of whatever muscular power remains, and by various forms of stiffening operations to substitute stiff but trustworthy for movable but unstable joints. Twenty years ago this end had to be accomplished by the use of apparatus. Now, however, operation has displaced braces, and internal been substituted for external splinting. In the shoulder it rarely happens that all the muscles attached to the scapula are paralyzed. The humerus may then be fused to the scapula so that the arm moves with the shoulder. The forearm may be suspended at a right angle on the arm, so that the hand may be brought to the face and various muscle transplantations may give a useful degree of motion to the fingers and thumb.

Paralysis affecting either the muscles of the abdomen or the back will, of course, result in curvature of the spine. The spine may be likened to the

mast of a boat, supported by four stays. If any or all the stays are removed not only does the mast become unstable of itself, but it is constantly subjected to the unopposed pull of what stay or stays remain, so that deformity is inevitable. There is, therefore, no good reason for delaying fusion operations on the spine after the expiration of the two-year period. One should never attempt to fuse the entire spine at one sitting. The fusion operation is difficult and severe, the subjects are unfavorable ones for operation, and one should always do too little rather than too much.

It might here, while I am dwelling on the severity of operative procedures, and the poor condition of the patients, be fair to paint with equal justice the other side of the picture. There is no more miserable spectacle than the paralyzed child who has been allowed to sit about, in whom deformities have developed unchecked. They are unable to make use of what muscular power they have, their circulation is bad, their bones are brittle and full of fat; if they have advanced curvatures of the spine their hearts are embarrassed and their lung capacity greatly decreased. They are mentally depressed. The general constitutional improvement that takes place in these patients as their deformities are relieved, their apparatus discarded, and as they regain the power of independent locomotion is nothing short of spectacular. As for the psychological effect, it is naturally incalculable. During the poliomyelitis epidemic of 1916, when I was serving as visiting orthopædic surgeon to the State health department, I saw what I suppose was as complete a collection of cripples of all etiologies, ages, and degrees of deformities as has met any one's experience. Save for the idiots, I remember no one for whom something could not be done. The oldest case I ever treated was one of paralysis of thirty-nine years' standing in a man fifty-two years old. After not having set foot to the ground for thirty-nine years, he is now walking with braces and crutches, though he complains that he "bogs down" in the mud of the Spring thaws.

Another boy of eighteen with an untreated, congenital club foot was sent to the hospital from a small town on the St. Lawrence river with the local reputation of being not only a cripple but the village idiot. As after several operations his foot gradually approached a normal appearance his mentality greatly improved. After his last operation, when, to the average observer, his foot looked normal, he had to be discharged from the hospital for too pressing attentions to a night nurse. I hear from a local doctor that he is the Don Juan of the St. Lawrence. Whether or not that particular result was desirable may be questioned. No one could deny that it was striking.

It seems to me, therefore, that provided a surgeon has sense and experience enough not to kill his patient by too hurried or too enthusiastic operative procedures, that all these patients are entitled at least to a chance of relief.

Parents frequently object when they are told that the number of operations and the time in hospital cannot be definitely predicted. I am speaking, of course, of only the worst cases. The patients themselves never do. They realize that they have only one body, and plenty of time, and no matter what

their age, if they are told the truth in advance, they almost never complain.

In this connection I wish to point out on behalf of surgeons in general the necessity of telling children the truth. The screaming terrified ones who are so hard to handle are those who have been assured that the doctor wouldn't hurt them, and then have had their fracture reduced without an anæsthetic. That may be an extreme example, but we all know a few bitter surgical facts, for instance, that ether is unpleasant to take, and to come out of, and that after appendectomies bellies ache. If children are told those simple facts in advance they usually are delighted to find the reality less than their imagination painted. In any case, the average child wants to be brave, and given a fair opportunity he will be. But he bitterly resents being lied to.

The deformities affecting the lower extremities are flexion contractions of the hips and knees, knock knees, and every possible variety of deformity of the foot. These may all be relieved by fairly well standardized operative procedures. It is the practice in some clinics to perform fusion operations on knees for dangle or flail extremities. The object is to relieve patients of their braces. I have never performed the operation without previously making the patient live with his legs in plaster for a month or so to see what life with a stiff knee could be. As a result I have performed the operation for that particular disability only twice in all my experience. Also, an astraglectomy and backward displacement of the foot properly performed, so that dorsal flexion of the foot is checked at a right angle, will lock the knee in extension, so that in many cases braces are unnecessary.

What I desire to emphasize are the three sharply differentiated phases of the disease, and what we may hope may be accomplished by treatment in each phase. If one keeps the pathology of each phase always in mind, one is less likely to become confused in treatment. No matter how badly neglected the patient or how advanced the deformity, something may always be done toward improvement.

In favorable cases surgical treatment may entirely mask the effects of the disease. In worse cases it may enable the patient to discard apparatus. In the worst cases it can hold out the possibility of independent locomotion. The disease this year is not nearly so severe as in 1916. I have not seen for years the terrible deformities that I saw then all over the state of New York. Surely such an improvement must mark a beginning in the education of the public and the medical profession. Once they have an understanding of the nature of the disease, when it no longer seems the utterly mysterious thing that it does now, the people will no longer rush frantically *from quack to quack* sacrificing the fortunes of the family to any one who promises a cure.

The public should know that only a small proportion of patients who contract anterior poliomyelitis are paralyzed at all. Of those paralyzed a large proportion get well. Of those who do not, the ones who are faithful and systematic in following the doctor's orders over long periods of time may be greatly improved. Owing to the replacement of braces by surgery only a very small number need expect to look, feel or act like a cripple.

OPERATIVE TREATMENT OF PARALYTIC GENU RECURVATUM

By WILLIS C. CAMPBELL, M.D., AND JOSEPH I. MITCHELL, M.D.

OF MEMPHIS, TENN.

GENU recurvatum, or exaggerated hyperextension of the knee, may develop following acute anterior poliomyelitis when the hamstring muscles and the gastrocnemius muscle are paralyzed and the quadriceps muscle is active. The deformity may also result from a compensatory effort to fix

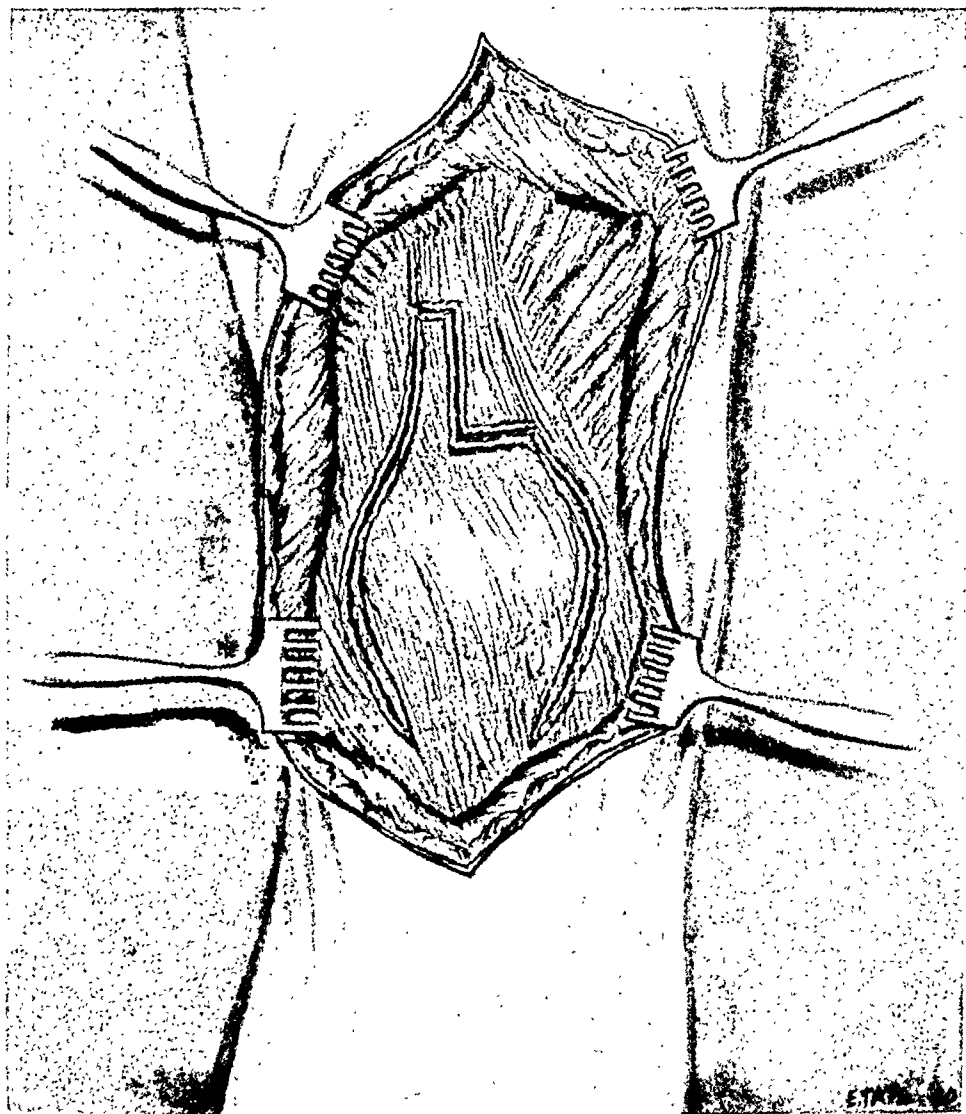


FIG. 1.—Incision over knee exposing the patella and the patellar ligament. The quadriceps tendon is divided by a Z-shaped incision.

the knee when all muscles of the thigh and leg are flaccid. Less frequently, hyperextension of the knee may occur as a sequel of spastic cerebral paralysis or of traumatic or other spinal-cord and peripheral-nerve lesions. A moderate degree of genu recurvatum is not incompatible with good function and under certain conditions may even be of advantage in stabilizing the paralyzed limb. If extreme hyperextension is present, however, standing and

walking become difficult or impossible without the aid of a brace or other apparatus.

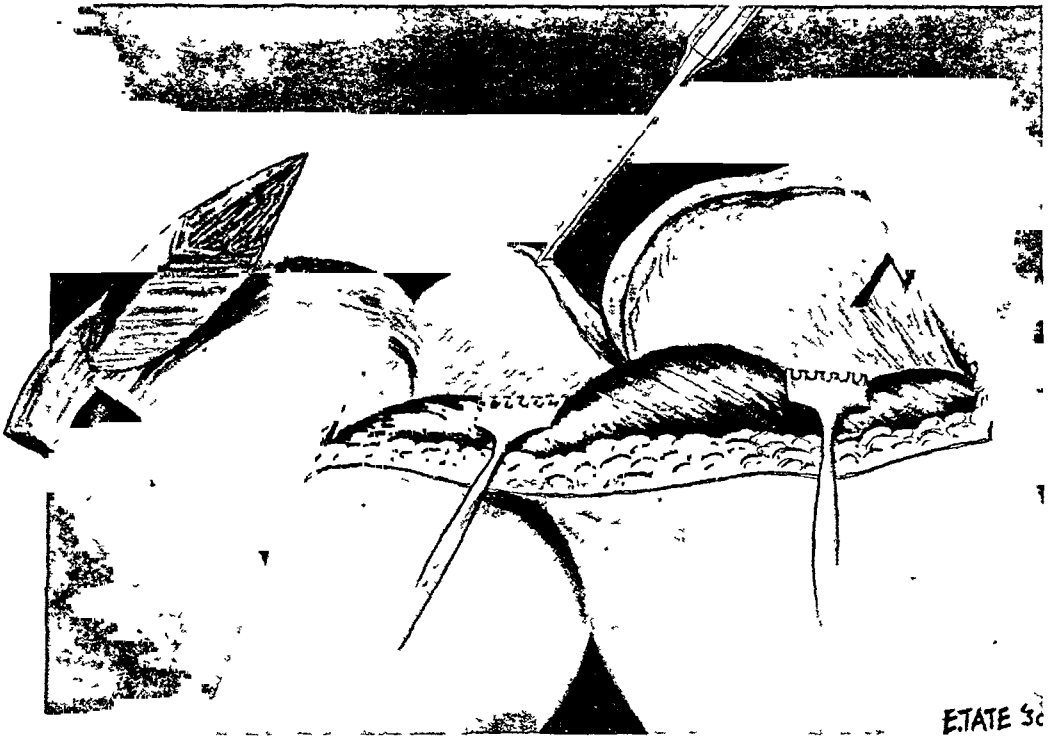


FIG 2—The patella is retracted downward and the cartilage and fibrous tissue are removed from the lower third of the patella. An osteotome is used to form a receiving cavity on the tibia.

An operation for the correction and prevention of hyperextension of the knee was described by one of us (W. C. C.) in 1918.¹ The mechanical prin-

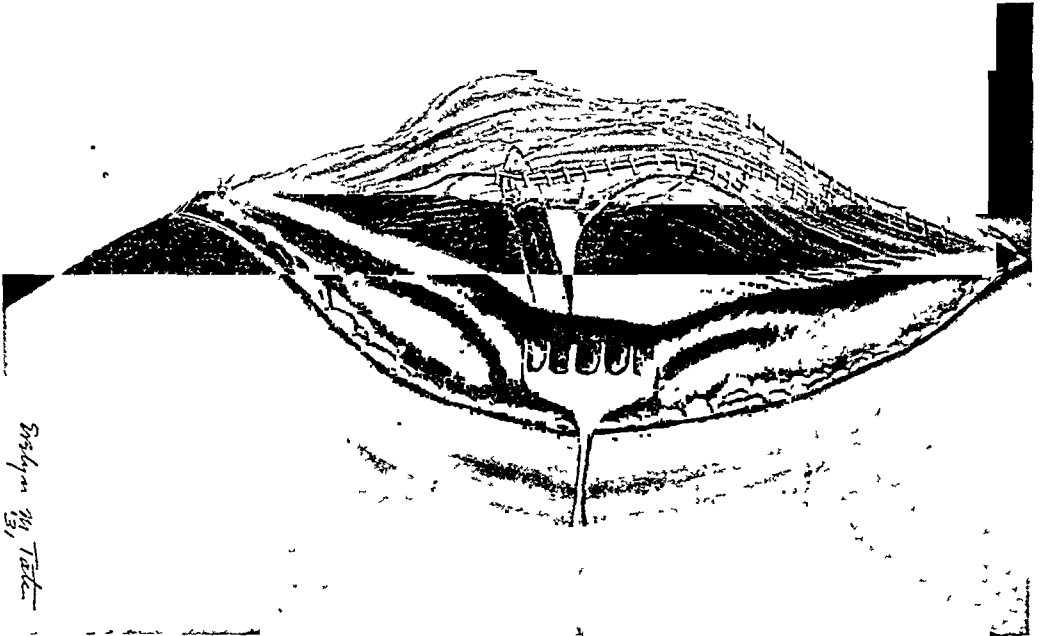


FIG 3—The patella is inserted into the cavity and sutured in position. The quadriceps tendon is reunited and the joint capsule closed. Note the bulging forward of the redundant patellar tendon.

PARALYTIC GENU RECURVATUM

ciple of the operation is to unite the lower end of the patella to the anterior aspect of the tibia; the upper two-thirds of the patella are left free to articulate with the femoral condyles when the knee is extended. A stop-joint is thus formed which prevents hyperextension of the knee in the same manner as the olecranon process of the ulna blocks hyperextension of the elbow. The description of this operation is believed to have been the first recorded instance in which a bone block was used to limit joint motion in a paralyzed limb, and it was from this procedure that the bone-block operation for drop foot was later evolved.

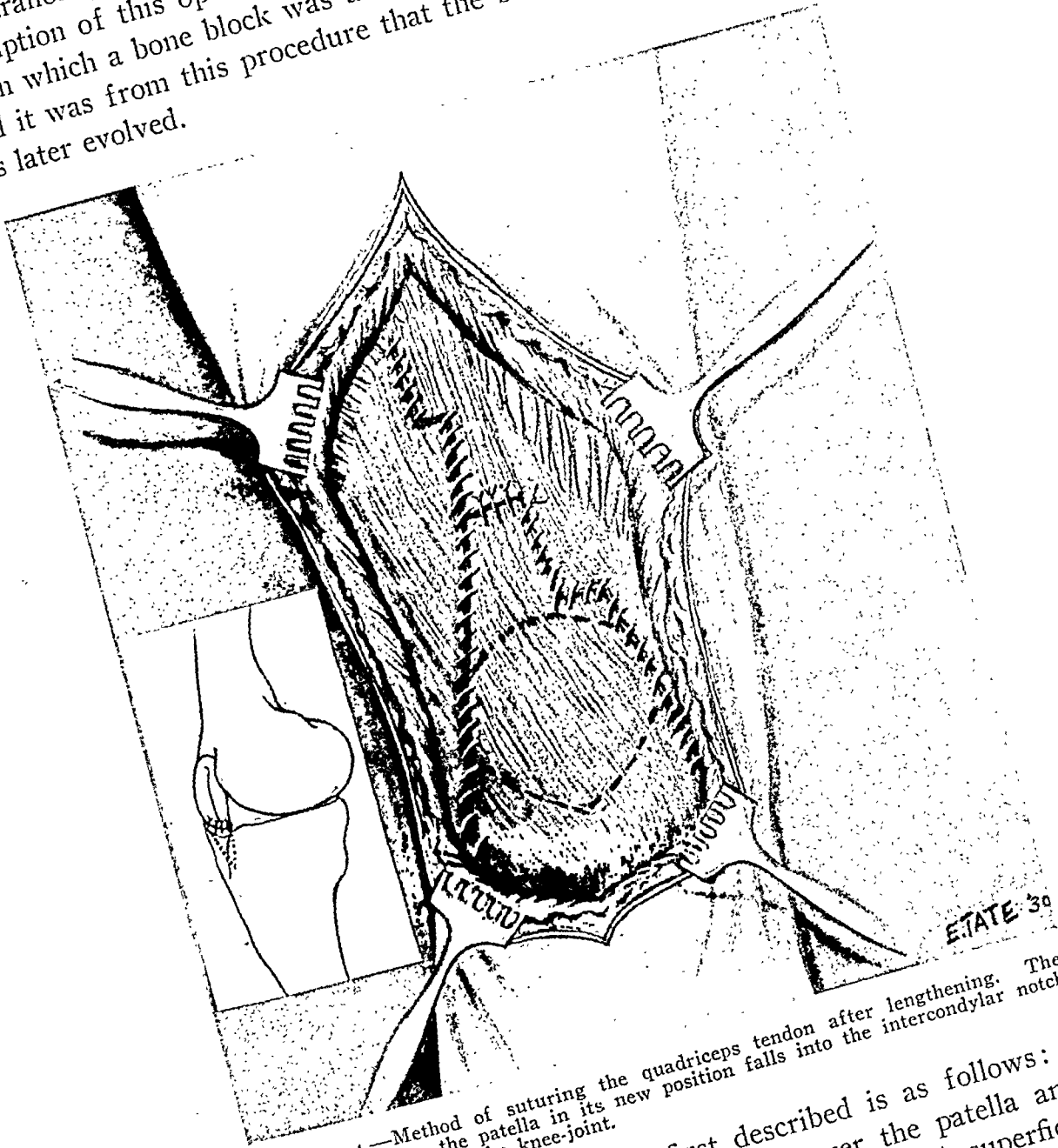


FIG. 4.—Method of suturing the quadriceps tendon after lengthening. The insert shows how the patella in its new position falls into the intercondylar notch to block extension of the knee-joint.

The technic of the operation as first described is as follows: A linear incision five or six inches in length is made over the patella and patellar ligament. The incision extends through the skin and superficial tissues which are retracted. The quadriceps tendon is divided above the patella by a Z-shaped incision. (Fig. 1.) The capsule of the knee-joint on either side of the patella is then incised and the patella retracted downward (Fig. 2), exposing the interior of the joint. The ligamentum mucusum is divided and a portion of the infrapatellar fat pad is excised. The cartilage covering the

lower one-third of the patella is removed to the spongy bone. The patellar tendon and the periosteum are stripped from the anterior surface of the patella for a distance of one-half to three-quarters of an inch. A cavity is then made on the upper anterior aspect of the tibia by driving an osteotome vertically downward and prying forward the portion of the tibia anterior to the chisel. The patella is inserted into the depression on the tibia thus made, and the periosteum of the patella is sutured to the periosteum of the tibia about the margin of the cavity. (Fig. 3.) The quadriceps tendon is reunited at neutral tension, the joint capsule sutured and the wound closed in

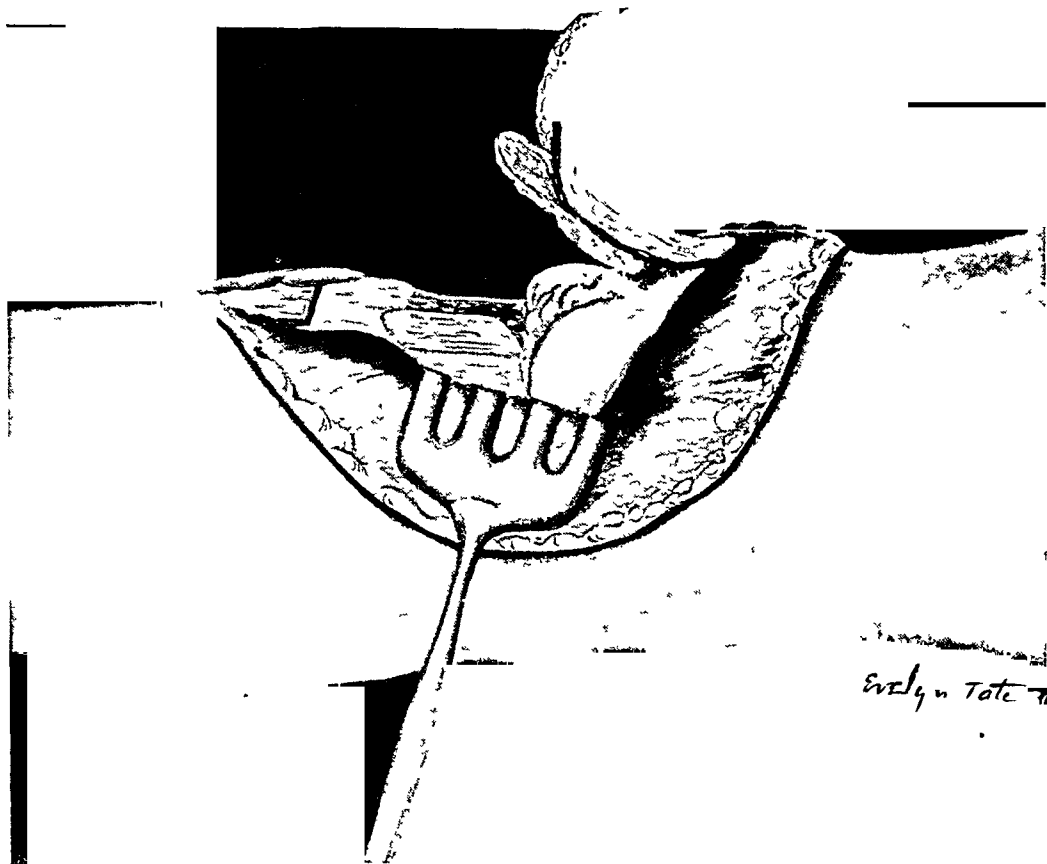


FIG 5—Technic of operation when quadriceps tendon is not divided. The patellar tendon is retracted upward and a flap of bone raised from the tibia, forming a shallow depression at this point

layers. (Fig. 4.) A cast is applied holding the knee at 160° flexion. After eight weeks a brace with a stop-joint at the knee is applied and worn until röntgenograms demonstrate that bony fusion is complete. The position in which the knees become blocked must be carefully observed and controlled throughout the period of post-operative convalescence. Complete extension or even slight hyperextension is essential. If the patella stops extension of the tibial on the femur before the position of complete anatomic extension is secured, the paralyzed limb will still be unstable and the knee will flex when weight is borne on the limb unless the patient supports his thigh with his hand.

A modification of the original technic, in which the quadriceps tendon is

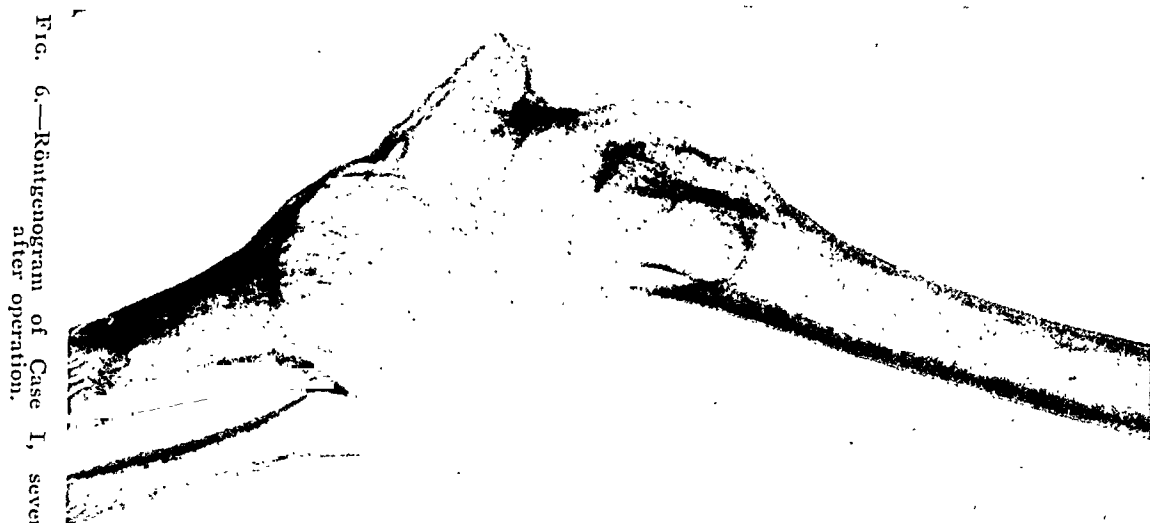


FIG. 6.—Röntgenogram of Case I, seven years after operation.

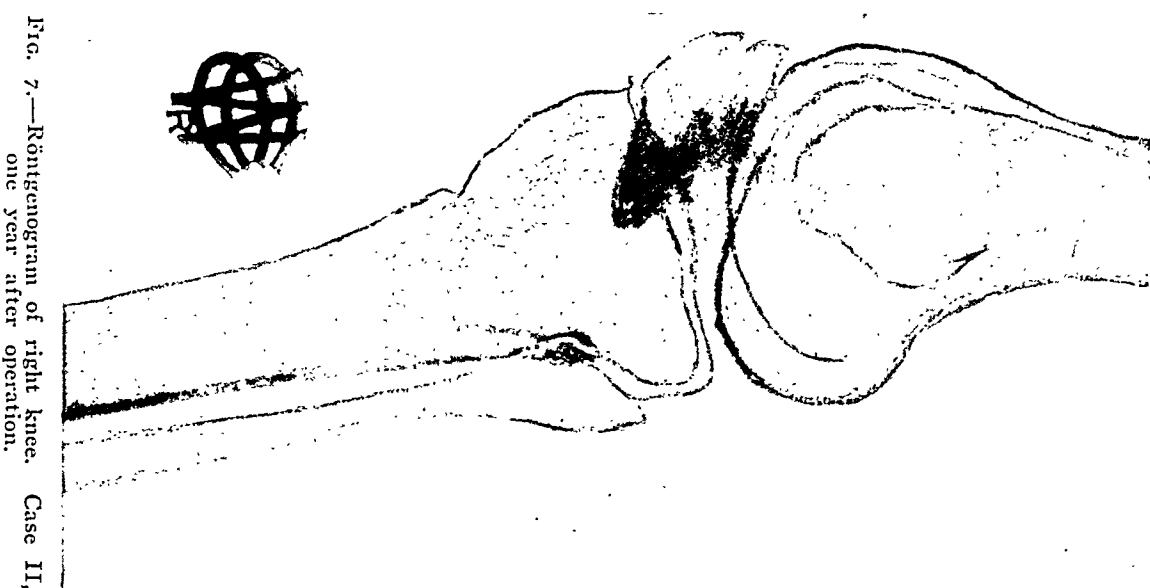


FIG. 7.—Röntgenogram of right knee, Case II, one year after operation.

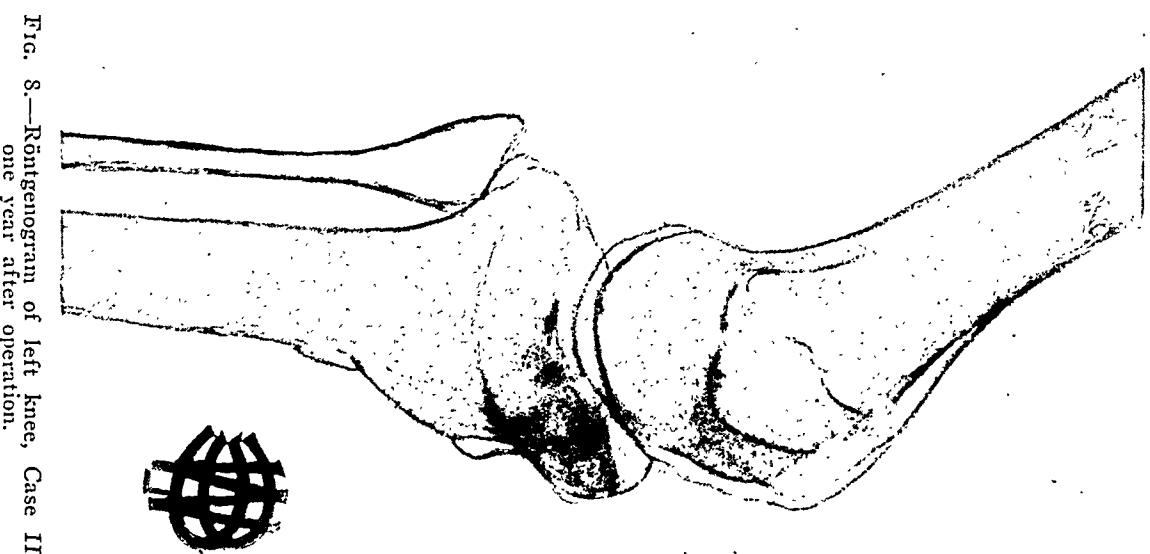


FIG. 8.—Röntgenogram of left knee, Case II, one year after operation.

not divided, has been employed by one of us (J. I. M.) in three cases. A longitudinal or transverse incision is made over the insertion of the patellar tendon. (Fig. 5.) The attachment of the tendon is freed from the tibial tubercle and the tendon and patella retracted upward, the infrapatellar fat pad being dissected from the tendon and pushed backward into the joint. A flap of bone is raised from the upper aspect of the tibia and a shallow depres-

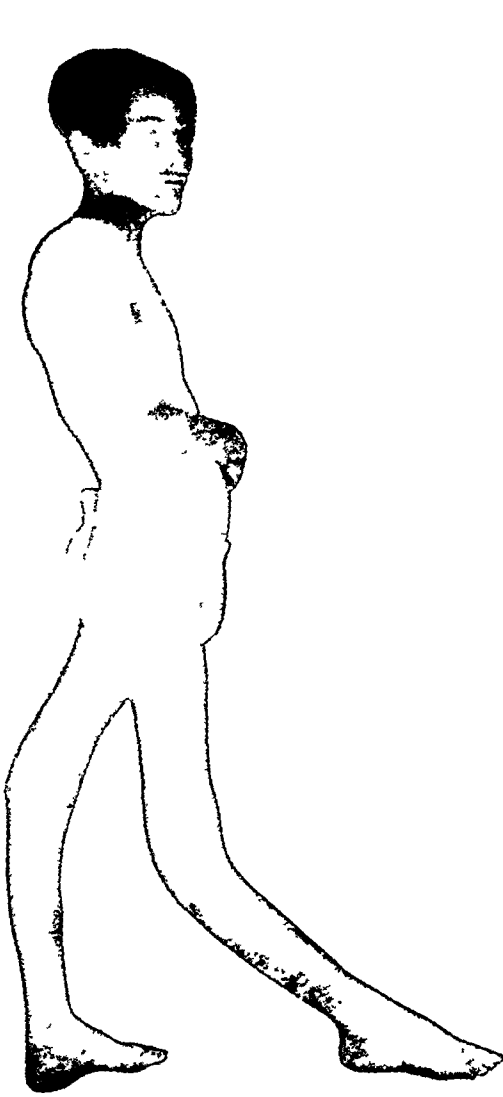


FIG 9—Photograph of Case III, showing bilateral genu recurvatum.

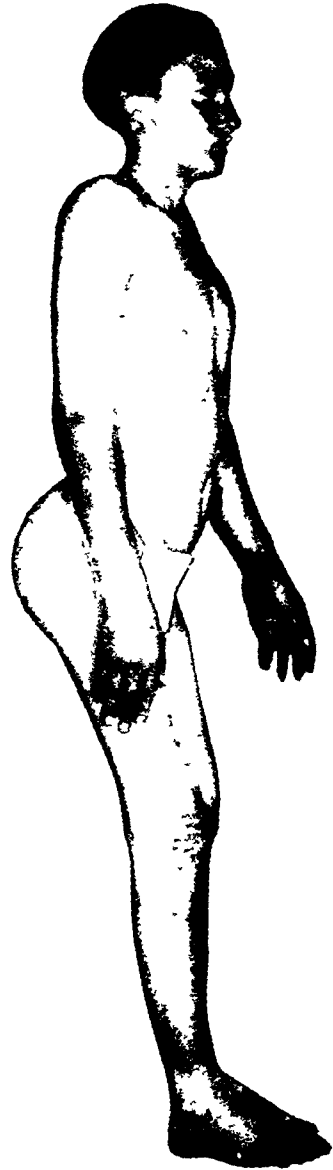


FIG 10—Same as Fig. 9, eight months after operation.

sion made in the bone at this point extending up to the articular surface. The lower one-third of the patella is denuded of cartilage and tendinous attachments and this portion of the bone placed in contact with the denuded area on the tibia. The flap of bone is replaced and the fragments of cancellous bone, removed in making the excavation, are packed around the lower margin of the patella. The tendon is pulled taut and the patella maintained

PARALYTIC GENU RECURVATUM

in its new position by suturing the tendon to the periosteum of the tibia at a lower level.

Recently Mayer² has described a modification of the operation in which a bone graft from the tibia or femur is placed in contact with the upper surface of the tibia and the denuded patella. He reports excellent functional results from the procedure. Gill³ has also reported satisfactory result following the construction of a strong check ligament from the posterior portion of the periosteum of the femur and the fascia lata. Other procedures which have been employed are arthrodesis of the knee and supracondylar osteotomy of the femur.

CASE REPORTS.—CASE I.—A girl, aged fourteen years, was examined December 2, 1919. Following an attack of infantile paralysis when three years old both legs were flaccid and since that time the girl had walked only with crutches. The examination showed atrophy and loss of muscle power in both legs with genu recurvatum on the left side and genu valgum on the right. An arthrodesis of the tarsal joints of the left foot and osteotomy of the right femur were performed January 23, 1919. The left knee was operated upon March 25, 1922. Bony fusion of the patella to the tibia was secured with improvement in function (Fig. 6) although the patient has continued to wear a brace on the left leg and uses crutches.

CASE II.—A girl, aged fifteen years, was examined August 28, 1923. Following an attack of infantile paralysis when eight years old, both lower extremities were almost flail. On examination she presented bilateral equinovarus deformity, exaggerated hyperextension of both knees and a severe paralytic scoliosis. On September 15, a triple arthrodesis and drop-foot operation was performed on the left foot; at the same time the routine fusion of the patella to the tibia was carried out on the right knee. On December 7, a similar operation was performed on the left knee and the deformity of the opposite foot was corrected. Still later, the spinal curvature was partially corrected and the dorsal region of the spine fused. Bony ankylosis of the patella to the tibia was secured in each instance with considerable improvement in function of the knees. At the present time, the girl uses crutches, except when walking very short distances, because of the generalized muscular weakness, but the knees are stable (Figs. 7 and 8) and she does not complain of pain or other inconvenience.

CASE III.—A boy, thirteen years of age, was admitted into the hospital October 31, 1923. When six years old he had had an acute febrile illness which was not diagnosed, but which was followed by weakness and progressive deformity of both legs. (Fig. 9.) Examination showed muscular atrophy and flaccid paralysis of both lower extremities



FIG. 11.—Röntgenogram of Case V, one year after operation.

with pronounced recurvatum of both knees which interfered greatly with locomotion. November 2, both knees were operated upon. On the right side the routine technic was employed; on the left leg an osteotomy of the femur was done, removing a wedge from the supracondylar area with the base posteriorly. The stability of both knees was improved. (Fig. 10.) However, the functional result on the right leg, in which fusion of the patella to the tibia was accomplished, was superior to that of the left leg, in which the osteotomy was performed.

CASE IV.—A girl, sixteen years of age, was seen June 3, 1924. She had had acute



FIG. 12.—Photograph of Case VI, showing genu recurvatum and equinus deformity of the left foot.

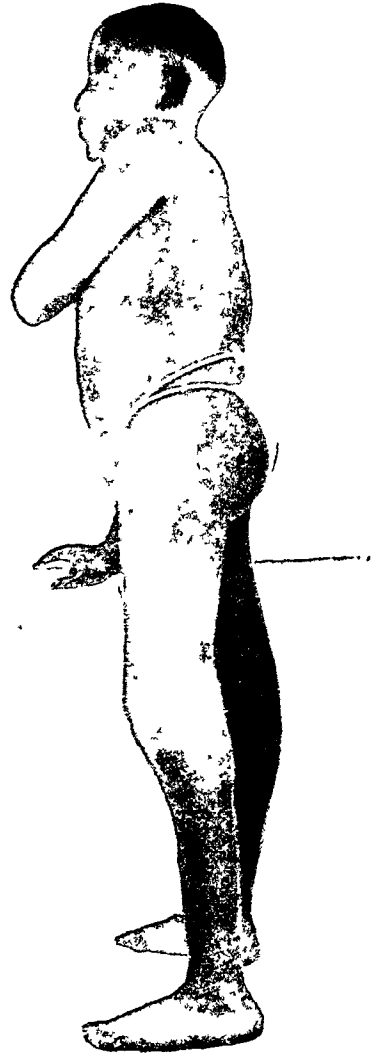


FIG. 13.—Same as Fig. 12 ten months after operation.

anterior poliomyelitis during infancy. In 1920 flexion contracture of both hips had been corrected by operation. Examination showed extensive paralysis of both lower extremities, the right leg being practically flail below the hip. There was exaggerated hyperextension of the right knee when weight was borne, necessitating the use of a brace on that leg. The operation for fusion of the right patella to the tibia was performed June 4, and an arthrodesis and drop-foot operation was performed on the left foot. The results of both operations were good, the patient being able to discard her brace, and she now walks with a less noticeable limp.

PARALYTIC GENU RECURVATUM

CASE V.—A girl, aged seventeen years, was examined February 27, 1928. At the age of two years she had contracted an acute febrile illness resulting in extensive flaccid paralysis of both lower extremities. The left leg could be hyperextended at the knee; there was slight voluntary power in the hamstring muscles, but the quadriceps muscle and all muscles below the knee were completely paralyzed. The left foot was contracted in a position of equino varus. The right leg was flail and there was a right talipes varus. There was also a right dorsal, left lumbar scoliosis of paralytic origin. The first operation, which was performed on March 1, consisted of an arthrodesis and bone block on the left foot. On April 12 an arthrodesis and drop-foot operation was performed on the right foot and at the same time the left patella was fused to the tibia. The technic of the operation in this case was modified in that the patella was exposed from below and the quadriceps tendon was not lengthened. The immediate and eventual results of the orthopedic operations were satisfactory from clinical and röntgenogenic standpoints. (Fig. 11.) On the day following the second operation, the patient developed an acute abdominal condition which was diagnosed appendicitis; an emergency appendectomy was performed by the general surgical consultant. Following this operation complications arose making other abdominal operations necessary and keeping the patient practically bedridden for the rest of her life. She died at home thirteen months later from what was reported by her attending physician to have been a brain abscess. Unfortunately, a post-mortem examination was not obtained.

CASE VI.—A Negro boy was first seen August 30, 1922, at the age of three years. The history suggested a cerebral birth injury from a difficult instrumental delivery during which the left humerus was fractured. Spasticity with adduction contracture of both legs prevented the child from walking and there was, in addition, equinus deformity of both feet and dorsal dislocation of both hips. The dislocation of the hips was reduced by closed manipulation. After dismissal from the hospital, the child was not brought back for observation until June 4, 1928. The

examination then showed extreme recurvatum of the left knee. The knee could be hyperextended to 100° ; flexion of the joint was limited to about 10° past the straight position. The left foot was contracted in the equinus position. (Fig. 12.) On the right side the thigh was adducted, externally rotated and flexion of the knee was limited to 90° . There was also a right dorsal left lumbar scoliosis. Röntgenograms on this date showed the head of each femur to be in the acetabulum. Operative treatment was advised but was not accepted until February 2, 1929, at which time the left tendo achillis was lengthened, correcting the equinus deformity. A brace with a stop-joint at the knee was then applied and flexion of the knee gradually developed. On February 27, 1930, the left patella was arthrodesed to the tibia, the technic employed being the same as that used in Case V. When last observed, July 20, 1931, fusion of the patella was not solid, but the function of the leg was greatly improved. (Fig. 13.) Only slight hyperextension of the knee was demonstrable and flexion was possible to almost 90° . The boy walks with crutches.

CASE VII.—A girl, aged sixteen years, was examined July 26, 1930. As a result of

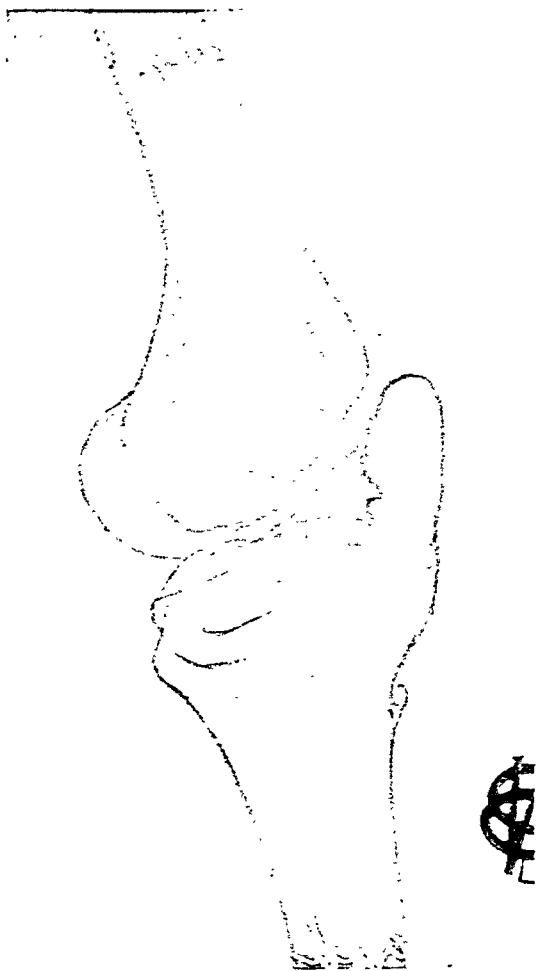


FIG. 14.—Röntgenogram of Case VII, two months after operation.

infantile paralysis when two years old, the left leg was almost completely flaccid. The limb was two inches shorter than the right with a dangle foot and hyperextension at the knee. A tarsal arthrodesis and drop-foot operation was performed July 29. The patella was arthrodesed to the tibia on October 7. In this case as in Cases V and VI the quadriceps tendon was not lengthened. Following eight weeks' immobilization, the patella was clinically fused and the röntgenogram showed good approximation and new bone production. Motion in the knee-joint is restricted to about 45° flexion, which will probably increase. (Fig. 14.) The knee blocks in the extended position, but the patient will continue to wear a brace for several months.

CONCLUSIONS

Paralytic genu recurvatum results in most instances from a combination of muscular weakness and the static force of weight-bearing.

When due to anterior poliomyelitis, severe degrees of hyperextension of the knee occur usually in those individuals in whom the paralysis is of severe grade and wide distribution. The deformity is often associated with other deformities in the lower extremities and trunk.

The operation of fusion of the patella to the tibia in selected cases offers a technically simple and reliable method of treatment. Seven cases are reported, in one of which the operation was performed on both knees. The functional results of the operation are superior to those obtained from supra-condylar osteotomy of the femur and are believed to be more permanent than can be secured from any form of ligamentous fixation. The additional surgery required for employing an autogenous bone graft is thought to be unnecessary. Should it be deemed inadvisable to lengthen the quadriceps tendon, the patella can be approached from below without entering the knee-joint proper, the procedure then being practically extra-articular.

REFERENCES

- ¹ Campbell, Willis C.: An Operation for the Correction and Prevention of Paralytic Genu Recurvatum. *J.A.M.A.*, vol. lxxi, p. 967, September 21, 1918.
- ² Mayer, Leo: An Operation for the Cure of Paralytic Genu Recurvatum. *Journal of Bone and Joint Surgery*, vol. xii, p. 845, October, 1930.
- ³ Gill, A. Bruce: Operation for Correction of Paralytic Genu Recurvatum. *J. B. and J. S.*, vol. xiii, p. 49, 1931.

CHRONIC TUBERCULOUS POLYARTHRITIS

BY MORRIS B. COOPERMAN, M.D.

OF PHILADELPHIA, PA.

FROM THE ORTHOPEDIC SERVICE OF MT. SINAI HOSPITAL, PHILADELPHIA

THERE is scarcely a subject in medicine so difficult of etiological interpretation as chronic arthritis. Although a great deal of clinical and experimental data are available in which highly selective strains of streptococci have been incriminated, yet in the symptom complex designated as rheumatoid or chronic infectious arthritis the exciting cause can, at best, only be surmised.

It is well known that a specific bacterial excitant from a known focus of infection may provoke an acute polyarthritis, maintain possession of the joints and produce the chronic, inflammatory changes.

In many instances, the removal of the local focus harboring these organisms and the administration of specific vaccines are followed by a freedom from recurrences and the relief of the patient from the joint disabilities. On the other hand, there are many cases in which the clinical manifestations in the joints may be indistinguishable from those of the favorable group; the removal of the chronic local infection, if found, fails to free the patient from the arthritis and the disease progresses. All of us are familiar with such cases.

The reasons offered for these unfavorable results are still controversial and speculative. Some attribute it to the persistence of foci of infection in inaccessible regions; others have advanced the theory that the joints themselves may act as secondary foci of infection. This is hardly tenable since there has been no substantial proof to indicate that joints can act in this manner. It is held by an important French school, headed by Poncet and Leriche, that a large percentage of cases of rheumatoid arthritis is due to the action of attenuated strains of tubercle bacilli or toxins derived from some latent tuberculous focus in the respiratory system or elsewhere. According to these investigators, the inflammatory reactions, excited by this form of tuberculous infection, are indistinguishable clinically and pathologically from rheumatoid arthritis.

I am in accord with these views, as will be illustrated by a report of a small series of cases recently studied.

Historical.—Bonnet, in 1845, called attention to the transformation of rheumatic joints into true white swelling. The medical writing of this period conveys the impression that the clinicians were aware of an ill-defined relationship between tuberculosis and chronic arthritis.

In 1854, Charcot crystallized these views, calling attention to the great mortality from tuberculosis among patients suffering from chronic rheumatism. Again, in 1864, he emphasized the important part that scrofula played in the family history of patients suffering from chronic, progressive arthritis and remarked upon the incidence of pulmonary tuberculosis in such cases.

In the early 'eighties, Grocco, an Italian clinician, pointed out that tuberculous patients may develop joint disease without tubercles, cold abscesses or complete destruction of the joints. In 1892, he reported nine cases of tuberculous rheumatism and commented upon the uselessness of salicylates in such cases.

Poncet's first contribution, entitled "Chronic Tuberculous Rheumatism," was presented to the French Surgical Congress in 1897. His view met with great opposition. The existence of chronic tuberculous polyarthritis was denied. Patient and painstaking accumulation of laboratory and clinical facts with their careful presentation before numerous French societies stimulated a clinical interest in this subject and it has won a foothold as clinical entity in France and Germany.

In 1909, Poncet and Leriche published their classic contributions on "Tuberculous Rheumatism and Inflammatory Tuberculosis," and in the past decade many articles and case reports on the subject have appeared in the foreign literature.

In American literature one is impressed by the paucity and barrenness of statistics regarding the relationship between tuberculosis and chronic arthritis. In looking over the statistics furnished by the arthritic clinics in various parts of this country practically no mention is made of tuberculous rheumatism. Neither is any statement made regarding a differentiation between tuberculous polyarthritis and the ordinary infectious forms. It is highly probable that, included in their statistics, a certain percentage could be isolated, providing special examinations such as arthrotomy, biopsy studies and guinea-pig inoculations were performed.

A review of the more recent literature gives us an impressive array of case reports indicating that tuberculous polyarthritis is not uncommon. Brief mention is made of the following contributors to the subject: Edsall, Harvey and Hall, Mouriquand, Mitchels, Valentin, Betchov, Reitter and Lowenstein, A. M. Cohn, R. Gautenberg, J. J. Viton, J. A. Crucian, and L. Charosky and MacKinnon. These references are enlightening and show convincingly the reality of this clinical entity.

It should be emphasized that chronic, tuberculous polyarthritis is, in its evolution, clinical behavior, anatomical and pathological structure, and by X-ray, indistinguishable from the streptococci arthritides.

Early and even advanced cases are exceedingly difficult to place etiologically and hence are the source of a high percentage of error.

We are in the habit, because of our academic training, of looking upon tuberculous arthritis as a systemic disease with a tendency to monarticular localization, the clinical and pathological characteristics of which need not be detailed here.

When the patient exhibits the disease in a multiple form, which may simulate, clinically, ordinary chronic arthritis, we are prone to view the tuberculous origin with skepticism, or, more likely, not to consider it at all because of our preconceived notions of bone and joint tuberculosis in general.

CHRONIC TUBERCULOUS POLYARTHRITIS

This report is concerned with records of four cases of chronic, tuberculous polyarthritis of long standing, the discovery of whose true nature was made possible only by arthrotomy, tissue study and animal inoculations.

CASE I.—D. B., male, aged forty-eight, was admitted to the hospital July 8, 1928, suffering from chronic polyarthritis of about eight months' duration. The onset was sudden and the cause unknown. Dental extraction and tonsillectomy six months previously failed to effect relief or a cure. The patient had had chronic, pulmonary tuberculosis for many years; activity was evidenced by the presence of tubercle bacilli in the sputum. Family history unimportant and irrelevant.

He was emaciated, anæmic, male adult weighing 125 pounds. The mouth was œdentulous and tonsils were enucleated. His chest was of the phthisical type; both apices were involved in a tuberculous process, confirmed by physical and X-ray

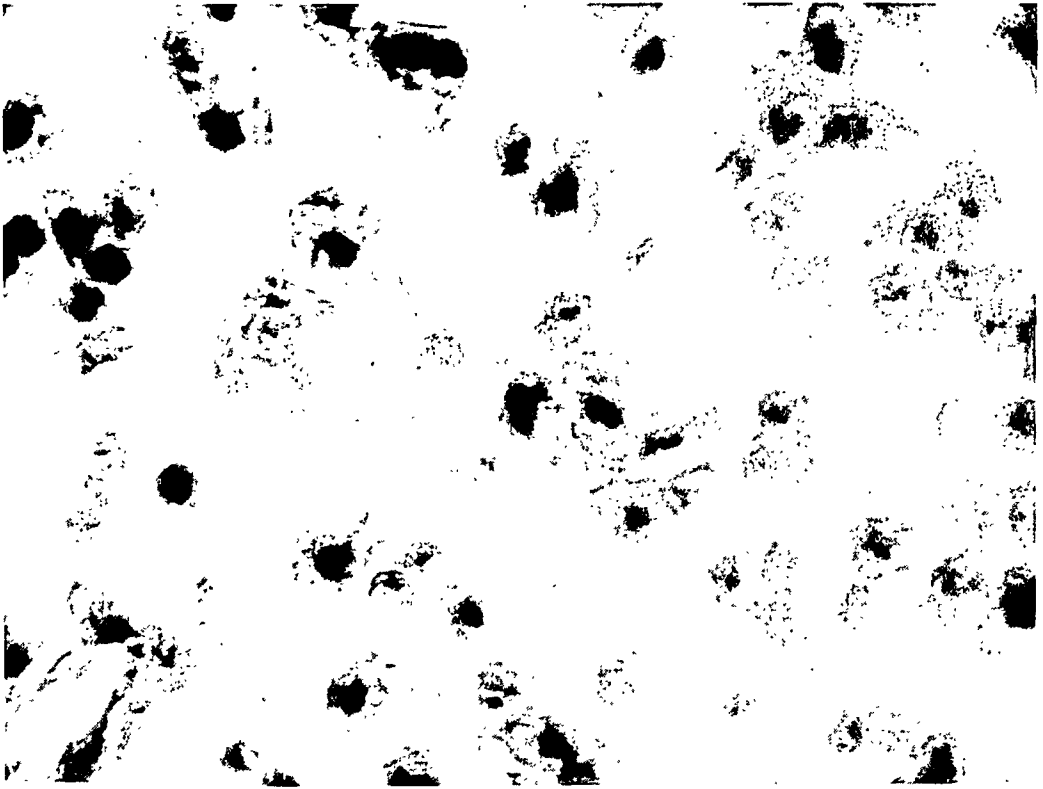


FIG. 1.—Peculiar large cell infiltration with eccentric nuclei and acidophilic cytoplasm. Gelatinous œdema in a case of tuberculous polyarthritis.

examinations. The heart was normal in size, shape and position; tones were of poor quality—no murmurs were audible. The abdomen was negative. The extremities exhibited polyarthritis of the infectious type with periarticular proliferation, limited motion, marked arthritic muscular atrophy and typical deformities. The involved joints included the shoulders, elbows, wrists, phalanges, knees, ankles and tarsals.

The knee-joints were swollen and fluctuated on palpation. Diagnostic tap revealed a cloudy, yellow exudate, which, upon microscopical examination, proved to be negative for acid-fast bacilli and sterile on culture for other organisms. The X-ray examination of the knee-joints showed bone atrophy; normal outline and narrow spaces.

Laboratory studies showed sputum positive for tubercle bacilli; urine contained traces of albumen and casts; blood revealed a secondary anæmia; Wassermann test, negative, and the synovial fluid showed a leucocyte count of 80 to 100 polymorphonuclears per H.P.F. The gastro-intestinal study, including X-ray examination, showed a displacement of the sigmoid to the right. Fæces were negative for parasites, ova and pathogenic bacteria. The prostatic smear showed three to five pus-cells per H.P.F. (Fig. 1.)

The patient was treated along conventional lines by salicylates, intravenous injections of neoarsphenamine for about six weeks, during which time his temperature ranged between 99° and 101°; pulse 80 to 110 and respiration 24 to 28. No improvement was noted under this treatment.

August 17, 1928, an arthrotomy of the right knee was performed through the split patellar route. The findings at operation were a thickened, congested synovial membrane, marked villous hypertrophy, fibrillation of the articular cartilages, slight pannus formation, disintegration of the internal semilunar cartilage and slight erosion of the articular surfaces of the tibia. A total synovectomy was performed by block dissection; the wound was closed in layers without drainage and a plaster case applied from toes to mid-thigh. The case was removed ten days after operation. The wound healed by primary union. The patient was discharged four weeks after the operation and sent to a convalescent home for post-operative care.

The patient re-entered the hospital on December 24, 1928, in excellent condition; right knee showed a normal outline but marked restriction of movement. A synovectomy was done on the left knee with findings similar to those noted at the first operation. Post-operative course was uneventful, and the wound healed in two weeks.

A diagnosis of tuberculosis polyarthritis was made based upon the histological report furnished by Dr. Benjamin Gouley, which is as follows:

The synovial membrane is thickened by œdema and cellular infiltration. No definite tubercle or caseation is found, but the entire section is invaded, both diffusely and locally around blood vessels, by large endothelial cells, having rather deeply stained nuclei, pale and sometimes acidophilic cytoplasm. The œdema sometimes has a gelatinous or mucoid appearance. Occasional lymphocytes are seen, but generally only the large endothelial cell is present. Another striking feature is the intimal thickening of small arteries. It is not an inflammatory lesion, but rather a swelling and vacuolization of the media and intima and is identical with the vascular changes seen in tuberculosis in other viscera.

This patient has been recently discharged from the Hamburg Sanatorium after having been there for about six months. The knee-joints have retrogressed and are now practically in the same condition as they were prior to operation. They are swollen, boggy, painful and tender. Aspiration disclosed typical tuberculous pus. Results of the guinea-pig inoculation are not yet reported.

CASE II.—H. G., aged thirty-seven, male adult, first entered the hospital June 8, 1927, with the chief complaint of swollen joints, dyspnoea and generalized œdema. These symptoms were of four months' duration, during which time he had been continuously confined to bed.

Previous Medical History.—In 1917 while in military service in France he was confined to the regimental infirmary for rheumatism and kidney trouble; under treatment these conditions improved. In 1919, he had a recurrence of the above diseases which confined him to bed for four months. During the past ten years he had recurrent attacks of polyarthritis which responded to treatment.

He is single, denies venereal infection, smokes excessively and has been a hard drinker at times; family history is unimportant.

He is emaciated, anæmic, male adult. His face is swollen, eyelids are puffy. Teeth are bad and tonsils diseased. Crackling râles are heard over the entire chest. Impaired resonance and distant breath sounds are heard over both bases indicating a pleural effusion. The heart exhibits increased dullness to the left; apex beat in sixth interspace; heart sounds are distant and muffled. No murmurs are audible. These physical signs indicate pericardial effusion. The abdomen is negative. The shoulders, elbows, wrists, fingers, knees, ankle and tarsal joints are involved in an arthritic process of the chronic infectious type. The wrist and phalangeal joints are swollen and restricted in mobility. The knees are swollen, globular in contour, fluctuate on pressure; patellæ float, and mobility is restricted and painful. The ankle and tarsal joints are rigid. There is a

CHRONIC TUBERCULOUS POLYARTHRITIS

marked, generalized arthritic muscular atrophy. The skin over the lower limbs is waxy and glazed in appearance and pits on pressure.

Laboratory Examination.—Urine revealed albumen, both granular and hyaline casts; blood chemistry, normal; blood count indicated secondary anæmia; Wassermann test, negative; X-ray of chest showed extensive, peribronchial and slight alveolar infiltration throughout extending to the apices. The hilus regions are markedly infiltrated and contain a few calcified lymph-nodes. The left base is obscured by pleurisy covering the diaphragm, suggesting an effusion. A small pleural effusion on the right side obliterates the right costophrenic angle. The heart is enlarged to the left; aorta is normal.

He remained in the hospital for about one month during which time the temperature ranged between 98° and 100°; pulse 90 to 120, respirations 28 to 32. Under treatment he improved slightly and at the end of a month left the hospital against advice.

During the succeeding fifteen months he re-entered the hospital on four different occasions. On one of these admissions his diseased tonsils and teeth were removed but these measures failed to benefit him in any way. At one time because of the multiple involvement of many serous membranes (pleura, pericardium and synovial), a diagnosis of Pick's disease was made.

The knee-joints were tapped several times, yielding a serous exudate which showed no organism on culture or smear; no animal inoculations were performed.

On one occasion oxygen was injected into the knee and followed by X-ray. The findings were incomplete filling of the subfemoral bursa due to adhesions or masses in the sac, irregular and narrow joint spaces, suggesting cartilaginous absorption, and marked atrophy of the bones.

November 12, 1929, the right knee-joint was explored through a Fisher incision and a total synovectomy was performed. The findings at operation were considerable fluid and a large quantity of débris, cheesy in character, filling the cavity of the joint. The synovial membrane was markedly thickened and the villi profuse; the lateral margin of the articular surfaces were irregularly covered with a thick layer of granulation tissue. Irregular areas were seen over the lateral condyle and the mesial surfaces of the tibia, exposing bare bone. The internal meniscus was disintegrated and the crucial ligaments destroyed; large necrotic villi were present between the joint's surfaces. The synovial membrane was completely excised and the wound closed in layers without drainage.

The post-operative course was uneventful; healing was rapid and the results were excellent. Normal contour was restored; motion was considerably restricted.

Pathological Report.—The specimen contains a great many membranous pieces of tissue, having one smooth and glistening and another, rough, ragged and uneven surface. These tissues represent parts of a capsule and synovial membrane. There are a great many pieces of tissue of varying size and shape which can be roughly divided into two groups: The one consisting of very soft tissue which is friable and almost snow-white in color. When torn to pieces it has the appearance of flakes of soap. This part weighs approximately 27.2 grams. The other group consists of pieces of tissue, some of which are lemon-yellow in color, others pinkish and gray. The pink and gray surfaces are smooth and glistening, apparently lined with a serous membrane. The yellow specimens have the characteristics of fat tissue.

Microscopic Examination.—The membranous specimens show a dense infiltration with round cells; in some of the areas there is a very marked proliferation of endothelial cells. In several fields typical giant cells are seen. The picture is characteristic of chronic, tuberculous inflammation. There is also a very marked, acute inflammation as shown by numerous neutrophilic leucocytes. The snow-white, amorphous pieces of tissue consist of a fibrinous and leucocytic exudate. All sections show a large number of plasma cells, and large mononuclear cells of various types.

Further comment by Dr. Benjamin Gouley is as follows: This case shows histologically a typical caseous necrosis of the articular tissue (pannus formation) and it is

interesting to find such pathology in a joint that clinically presented the picture of ordinary arthritis deformans.

December 14, 1929, a synovectomy was performed on the left knee with findings similar to those in the previous operation. The post-operative course was uneventful. The knee-joints after these operations, while considerably restricted in mobility, gave rise to practically very little pain. Their contour was normal. Weight-bearing was commenced two months after admission and for the first time in many months he was able to stand on his feet. He gained in weight and his entire mental attitude changed from a cranky, cantankerous, irritable patient to a hopeful, buoyant individual. An interesting

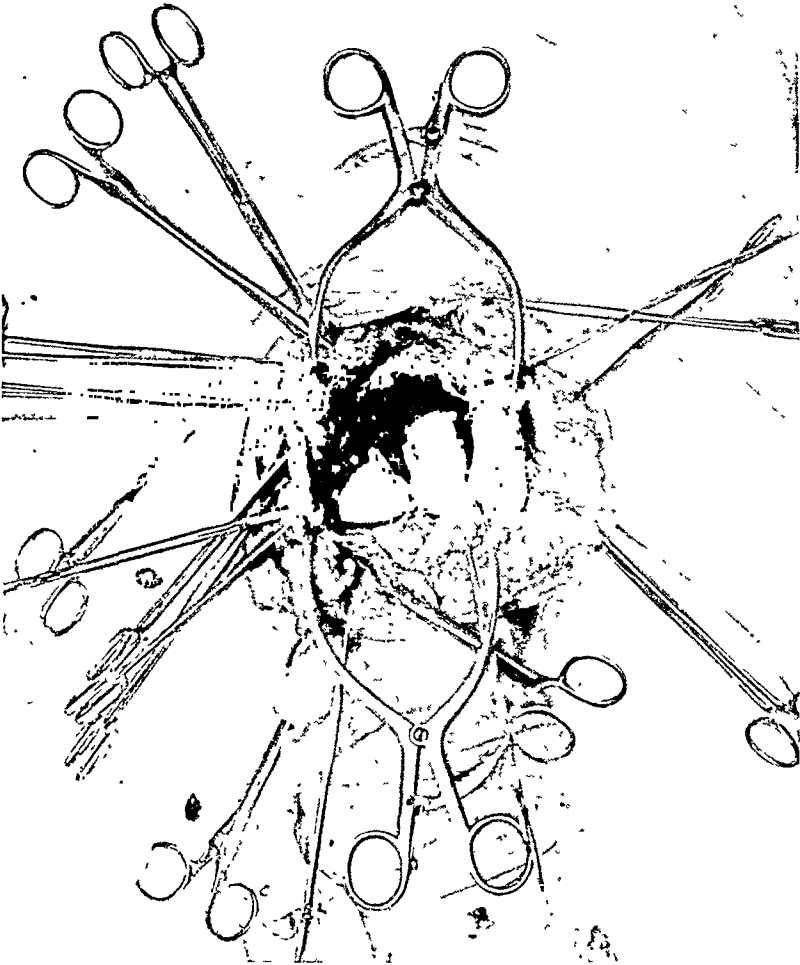


FIG. 2.—Tuberculous polyarthritis. Exposure of knee-joint showing cartilaginous erosion of external condyle of left femur and marked synovial thickening.

note in this case is the effect of these operations upon his heart. The heart action, which had been persistently hurried and weak throughout his entire hospital stay, became slower, more regular and improved in tone. His pulse rate, which had always ranged between 100 and 120, prior to operation, now ranged between 80 and 90. He was referred for convalescent care and gained twenty pounds in two months.

During the past year this patient has been under observation in the pulmonary and orthopædic clinics of the hospital. Repeated sputum examinations have been negative for tubercle bacilli, although clinically he has pulmonary tuberculosis.

CHRONIC TUBERCULOUS POLYARTHRITIS

CASE III.—B. P., aged sixty-five, female, admitted to the hospital September 8, 1930, suffering from polyarthritis of about six years' duration. For the past six months the left knee gave a considerable amount of pain and disability, which failed to respond to conservative treatment, baking, massage, salicylates and the like. The wrists, fingers, knees and ankle-joints exhibited signs of a proliferative arthritis. The left knee contained fluid. She was a short, stout, aged female, with œdentulous mouth, tonsils enucleated, subcrepitant râles over both bases; heart enlarged to the left, sounds of poor quality. Abdomen negative.

Laboratory Examination.—Urine showed a trace of albumen. Wassermann test,

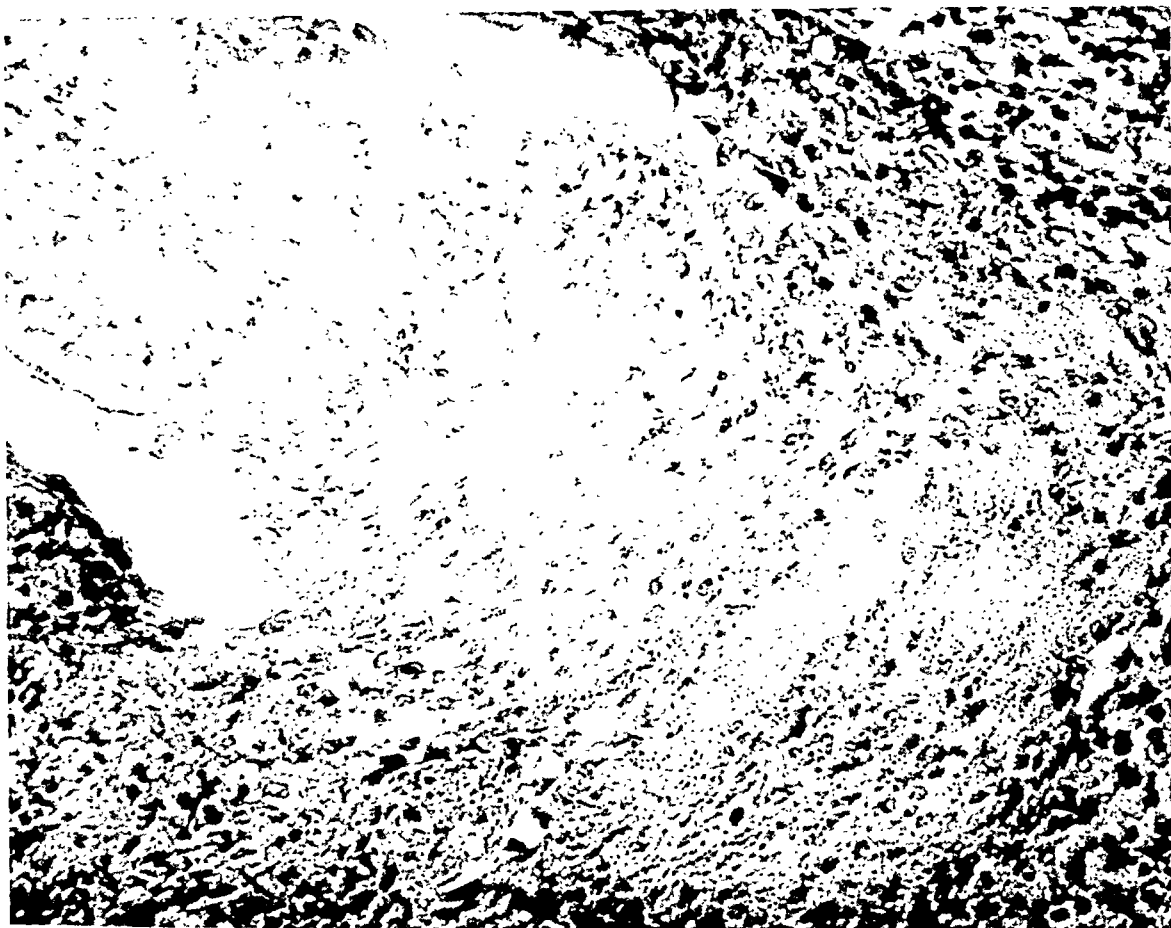


FIG. 3.—Conglomerate tubercle and granulation tissue in case of tuberculous polyarthritis.

negative; blood count, normal; blood chemistry, normal; X-ray examination of knee-joints revealed narrow joint space, absorption of articular cartilages, bone atrophy and marked soft tissue swelling.

Synovectomy was performed on the left knee in the usual manner; Fisher mesial incision. (Fig. 2.) Findings at operation: A large, necrotic, pedunculated fat pad occupied a position between the external condyle and the lateral articular surface of the tibia. Synovial membrane was markedly hypertrophied and congested. Lateral condyle was covered by a thick layer of pannus which extended over the articular surface, the removal of which exposed bare bone. The articular surfaces of the tibia exhibited absorption and necrosis in various regions. There was complete disintegration of the semilunar cartilages and the crucial ligaments were destroyed. Articular surface of the patella exhibited punched-out areas of cartilaginous absorption. The wound closed in the usual manner; cast was applied from toes to groin. The patient remained in the hospital nineteen days; wound healed by primary union. Follow-up in clinic shows that the left knee had marked restriction of motion with considerable disability and pain.

Histological report by Dr. Benjamin Gouley is as follows: The synovial membrane is markedly thickened, by congestion, œdema and a diffuse cellular infiltration. The

oedematous infiltrate is filled with large cells, apparently endothelial with deeply staining eccentric nuclei. (Fig. 3.) In some fields lymphocytes form a large percentage of exudate, but the large cells predominate and often to the complete exclusion of any other cell. Their cytoplasm has a slight tendency to take the acid stain. In a few tags of tissue attached to the synovial membrane definite tuberculous pathology is present with caseous necrosis, tubercle formation and fibrosis. The small blood-vessels often show a marked thickening of their intima, leading to spontaneous occlusion as is often seen in tuberculous pathology.

CASE IV.—F. K., aged forty-eight, female, was admitted to the hospital October 19, 1930, suffering from advanced atrophic arthritis of about ten years' duration. The present illness followed an incision of tonsillar abscess ten years ago. Until five years ago she was able to get around with some disability; for the past five years she had been bed-ridden. Several years ago she was in the hospital for about five months,



FIG 4—Tuberculous polyarthritis Many joints involved.

where every accessible focus of infection had been removed but without improving joint symptoms.

She was an emaciated, middle-aged woman, weighing about 90 pounds. The right lung exhibited amphoric breathing over the right apex; bronchial breathing over the right, middle lobe. The left lung was clear. Heart was normal in size, shape and position. Sounds were of poor quality; no murmurs. The abdomen was negative. An X-ray of the chest revealed parenchymatous deposits in both upper lobes, including apices. Enlarged nodes in the right hilus; calcified nodes in the left, supraclavicular region. The right pleura was thickened, diaphragm normal. Aorta was tortuous and sclerotic.

The shoulders were contracted against the chest-wall. Elbows were pathologically flexed and partly ankylosed. Wrists were boggy and swollen; phalanges were spindle-shaped, hyper-extended and relaxed. The knee-joints were globular, boggy and filled with fluid; patellæ float. The ankle-joints were swollen and rigid; feet were in equinus. (Fig. 4.) The spine was kyphotic and rigid. An X-ray of the knee-joints showed extensive destructive process with erosion of the articular surfaces, luxation of tibia,

outward. The spine showed marked atrophy of vertebral bodies; preservation of intervertebral spaces. Hip-joints showed absorption of articular surfaces. The skeleton showed marked atrophy.

Laboratory Examination.—Urine showed faint traces of albumen, occasional hyaline cast. Wassermann test, negative; blood chemistry, normal; synovial fluid from right knee, cloudy, yellow and turbid. Microscopical examination showed few epithelioid cells, fat globules, crystals resembling cholesterol and few lymphocytes. No acid-fast bacilli. *Lymph-nodes and spleen of inoculated guinea-pig, six weeks later, revealed acid-fast bacilli.*

The patient was transferred to the orthopædic service and resection of the right knee was done. Findings at operation were complete disintegration of the joint; thickened synovial membrane; flaky, yellow, fatty deposits lining the joint cavity; semilunar cartilages were completely destroyed; crucial ligaments preserved; tibia of dead-white

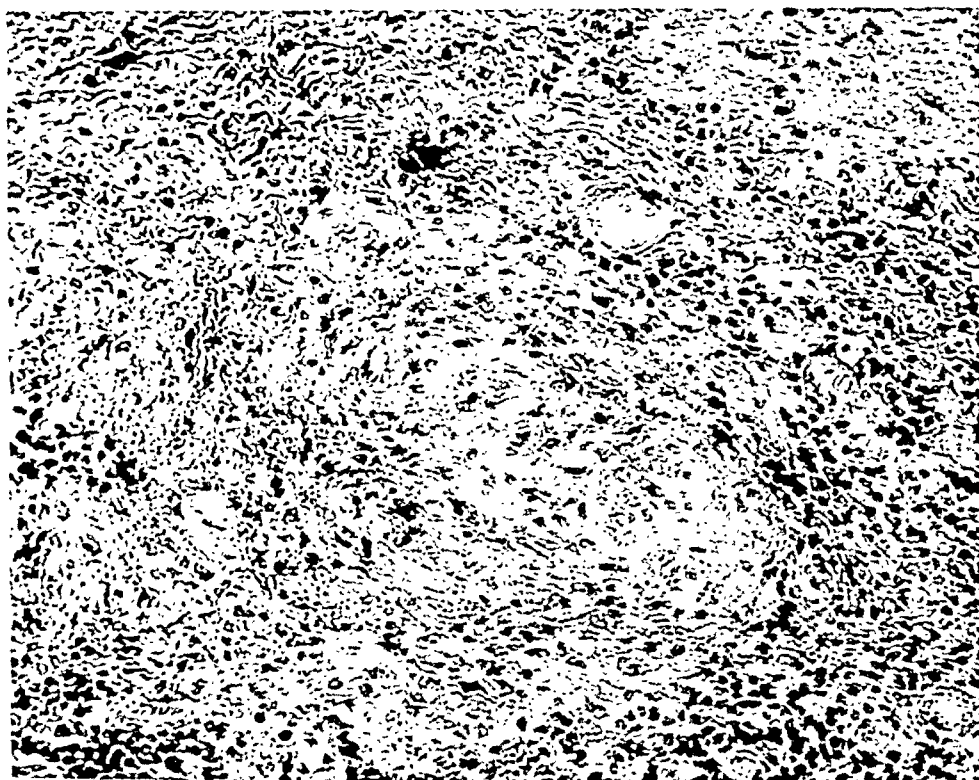


FIG. 5.—Tuberculous granulation tissue showing conglomerate tubercles.

appearance and was completely bloodless. The bone was sutured in the usual manner; case applied from ribs down to toes. This had to be removed at the end of two weeks as the patient objected. An abscess developed at the site of incision which exhibited typical characteristics of tuberculous pus. The patient was discharged March 29, 1931, in poor condition.

The histological report by Dr. Benjamin Gouley is as follows: The synovial membrane is greatly thickened by a hyaline fibrosis in which are scattered small foci of cells, often perivascular (around capillaries), consisting of round cells and a larger cell with eccentric nucleus, suggestive of a plasmocyte, except for its increased size and a slight tendency to acidophilic stain of the cytoplasm. (Fig. 5.) Two conglomerate tubercles are found which confirm the guinea-pig test.

This case was perhaps the most startling of the entire series. It represents that type spoken of by Barker as primary, progressive polyarthritis—the most malign of all arthropathies. Cecil and Archer, who reported on 612 cases of chronic arthritis, found eighteen belonging to this particular

type. In none of these were they able to find the underlying, etiological factor. It is highly probable that in this series no actual tissue studies or pig inoculations were performed. Had they done so they might also have found tubercle bacilli to be responsible for this condition.

Comment.—Among the predisposing causes of chronic, rheumatoid arthritis, heredity, bad environment, anatomical type of individual, over-fatigue, *etc.*, have all been emphasized as important factors. The disease occurs in thin, asthenic, young adults with the narrow, costal angle, cold, clammy extremities and lowered blood-pressure. May not all of these symptoms be manifestations of a submerged tuberculosis, acquired in childhood and brought to the surface in adults, by such exciting factors as exposure, mental stress, physical exertion, acute intercurrent diseases and the like? In these patients tubercle bacilli or virus, attenuated and weakened by long habitation in a resistant host, flare up, invade the blood-stream and localize in predisposed tissue, usually serous membrane, where chronic, proliferative processes are excited.

Very little attention has been focused upon the relationship between latent tuberculosis and chronic arthritis. A careful examination of all patients suffering from chronic arthritis, including X-ray of the chest, may reveal, in a certain percentage of these, healed, latent or active foci of tuberculosis in the parenchyma of the lung, peribronchial lymph-nodes or hilus region, but the significance of these findings as the cause of the arthritis is rarely, if at all, given credence.

In discussing this matter with a few clinicians I have been surprised with their views on the subject. They all seem to agree that the two diseases may co-exist in the same patient, but that they are unrelated and independent clinical entities.

Poncet and others maintained that articular inflammation is often the first evidence of metastatic invasion by toxin or bacilli from a distant, focal lesion of tuberculosis. The inflammatory changes in and around the joint are due, in a great majority of instances, to the virus; the synovial exudate does not contain tubercle bacilli, neither do they develop in the joint structures. Such a joint eventually may develop into a true tuberculous joint with bacilli, tubercles, giant cells, *etc.* The pathological process may be acute, subacute or chronic; one joint may suffer or a number of joints may be simultaneously involved.

The disease is most apt to arise after operation on tuberculous glands or bone, or it may develop in the course of any acute intercurrent infection (influenza, pneumonia, *etc.*). The articular lesions do not show the specific picture of giant cells and tubercles; the histological picture cannot be distinguished from that of ordinary inflammation, yet these lesions can often be proven by experimentation to be tuberculous.

MacCallum states that the occurrence of inflammatory reaction, caused by avirulent strains of tubercle bacilli or virus, resembles rather closely that

which follows the invasion by non-pyogenic coccal infections. It is a process entirely different from that found in the specific picture of tuberculosis.

Calmette and Valtis, in a recent contribution on "Filterable Elements of Tuberculosis Virus," maintain that the disease called tuberculosis and characterized by the presence of giant cells containing bacilli and of tubercles in various organs, is only the chronic form or end stage of an infection caused by an ultra virus, whose elements are at first invisible but gradually become non-acid fast, dust-like bodies and, if circumstances are favorable for their growth, later develop into tubercle bacilli. Serious effusions into the pleural, pericardial, peritoneal and synovial cavities appear to be caused by the ultra-virus exclusively. In many of these cases it is extremely difficult to find acid-fast tubercle bacilli.

In discussing inflammatory tuberculosis, MacCallum makes this highly significant assertion: It occurs in individuals who have had an old focus of disease and who may therefore be thought of as hypersensitive or immunized. The inflammation may be inconspicuous if the dosage be small. Showers of bacilli in great numbers cause the most profound intoxication, and set up destructive processes everywhere. In persons whose resistance to tuberculosis is high the reaction of the joints to the infection, or toxemia, may be mild and pursue a subacute or chronic course. Such reactions simulate the effect of the occasional intermittent escape of non-pyogenic streptococci, gonococci, staphylococci and the like. In the involved joints abundant vascularization appears on the free surfaces with thickening of the synovial membrane, villous hypertrophy and the formation of pannus or granulation tissue over the articular cartilages. This granulation tissue bears a striking resemblance to that produced by other infections; it may exhibit distinctions which may be recognized histologically. It is perhaps more thickly infiltrated with large and small mononuclear cells and contains few polymorphonuclear cells. In the advanced stage it is distinguished by its high content of scattered epithelioid and giant cells.

In our series of cases the characteristic features were the preponderance of endothelial cells and oedematous infiltration. The latter was almost mucoid or gelatinous. In some of these cases the large cells had eccentric nuclei and took the acidophilic stain. The cell infiltration was diffuse throughout all the sections examined and in some there was also perivascular infiltration. Some sections showed marked narrowing of the lumen of small arteries, due to spongy swelling of the intima. This non-infectious arteritis is seen in the neighborhood of tuberculous lesions and may be termed "contact arteritis." In addition to these findings tubercle formation and caseation were present, making the diagnosis obvious.

A few remarks regarding diagnosis of chronic, tuberculous polyarthritis are germane, and in this connection I wish to emphasize the importance of biopsy and guinea-pig inoculation in definitely establishing the identity in these cases.

In an article by Allen deForest Smith he states that a positive diagnosis

cannot be made by the ordinary methods so far in use. He pointed out that many cases of tuberculosis are commonly mistaken for chronic arthritis and synovitis, and reversely.

Allison and others affirm that the only positive proofs of tuberculosis are the pig tests, specific findings and the microscopic discovery of tubercle bacilli in the pus or tissues.

In view of the importance of this subject it is my firm belief that many cases masquerading as arthritis deformans, atrophic arthritis, rheumatoid arthritis, *etc.*, are really tuberculous processes. Our suspicions as to the tuberculous nature of these joints should be aroused if the history points toward a tuberculous background and the physical and X-ray examinations of the chest reveal tuberculous pathology. The X-ray examinations are practically of little value in the diagnosis, as are the Von Pirquet and Mantou skin tests.

In cases of chronic arthritis and other forms of systemic tuberculosis Reitter and Lowenstein have recently been able to isolate from the bloodstream the tubercle bacilli, by means of a special culture media. This will prove to be a distinct advance if confirmed by other observers. Until then, sole reliance must be placed upon tissue study and it is urged that more patients suffering from chronic arthritis be subjected to arthrotomies for the purpose of clearing up the diagnosis.

CONCLUSIONS

I fully realize the limitations of this contribution which is based upon such a small group of cases of proven tuberculous polyarthritis. Nevertheless, these cases are probably representative of a great many others labeled as arthritis deformans, chronic infectious arthritis, *etc.* I have endeavored to show that chronic, tuberculous polyarthritis exhibits the clinical picture resembling the ordinary forms of so-called rheumatoid arthritis. It is hoped that this communication will stimulate interest in the subject so as to clear up the etiology of a condition which in the past has been so baffling.

BIBLIOGRAPHY

- Allison: Nelson Loose Leaf Living Surgery, vol. iii, p. 27.
 Betchov, N.: Tuberculosis and Articular Rheumatism. *Revue Med. de la Suisse*, vol. xlii, p. 417, July, 1929.
 Calmette, and Valtis: Filtrable Elements of Tuberculosis Virus. *Zeitschrift fur Tuberkulose*, vol. lviii, pp. 385-466, Leipzig, November, 1930, p. 402.
 Cecil, and Archer: *J.A.M.A.*, vol. lxxxvii, No. 10, pp. 741-746, February 20, 1926.
 Cohn, A. M.: Poncet's Rheumatism and Generalized Pulmonary Tuberculosis. *Zeitschrift fur Tuberkulose*, vol. lviii, p. 172, October, 1930.
 Edsall: Still's Type of Chronic Arthritis. *Arch. Ped.*, p. 175, March, 1904.
 Gautenberg, R.: *Deutsche Medizinische Wochenschrift*, vol. lvi, p. 1902, Berlin, November 7, 1930.
 Harvey, and Hall: A Case of Multiple Tuberculous Arthritis Simulating Malignancy and Charcot Joint. *Radiology*, vol. xiii, p. 526, December, 1929.
 Lyle, Henry H. M.: *ANNALS OF SURGERY*, vol. lv, pp. 750-763, 1912.
 Matas, R.: Tuberculous Arthritis. *DaCosta's Modern Surgery*, p. 619.

CHRONIC TUBERCULOUS POLYARTHRITIS

- MacCallum, W. G.: A Text-book of Pathology, second edition, p. 650, 1920.
- MacKinnon: Canadian M.A.J., vol. xiv, p. 124, February, 1924; Abstract, Arch. of Surgery, vol. x, p. 219.
- Mitchels, G.: A Case of Tuberculous Articular Rheumatism. Zeitschrift fur Tuberkulose, vol. xxxiii, p. 279, February, 1921.
- Mouriquand, G.: Tuberculous Rheumatism in Children. Gazette des Hopitaux, p. 69, Paris, January 21, 1904; Abstract in Med. Review, London, p. 154, March, 1904.
- Poncet, and Leriche: Bull. et mem. de la Soc. Med. des Hop. de Paris, vol. lxviii, 1909.
- Reitter, and Lowenstein: Munichener medizinische Wochenschrift, Munich, vol. lxxvii, p. 1522, September 5, 1930.
- Smith, Allen deForest: J.A.M.A., vol. lxxxiii, No. 20, pp. 1569-1573, November 15, 1924.
- Steinberg, C.: Weiner Klinische Wochenschrift, vol. xliii, September 25, 1930.
- Valentin, B.: Zeitschrift fur Tuberkulose, vol. xxxvi, p. 336, July, 1922.
- Viton, Crucian, and Charosky: Tuberculous Meningitis Complicating Tuberculous Rheumatism. Semana Medica, Buenos Aires, vol. xxxvii, p. 1191, October 16, 1930.

KRUKENBERG TUMOR OF THE OVARY

By HOWARD W. STEPHENS, M.D.

OF SAN FRANCISCO CAL.

FROM THE DEPARTMENT OF SURGERY OF THE UNIVERSITY OF CALIFORNIA MEDICAL SCHOOL

FREDERICK KRUKENBERG,¹ in 1896, described a peculiar malignant tumor of the ovary to which he gave the term *fibrosarcoma mucocellulare carcinomatodes*. As the name implies, Krukenberg considered the tumor to be primarily a fibrosarcoma with elements in its structure resembling carcinoma. He described it as a solid ovarian tumor, usually bilateral, maintaining the form of the ovary, of myxomatous appearance, occurring in young and old subjects, growing slowly, usually with ascites, and eventually fatal by extension or recurrence. He described the structure as presenting small groups or a diffuse growth of large polyhydral or rounded cells with mucoid contents compressing the nucleus into a signet-ring form. He believed the tumor to be primary in the ovary.

Since the original description of Krukenberg, R. H. Major² has made perhaps the most noteworthy contribution to our knowledge of this tumor. He collected and studied fifty-five authentic cases and concluded that, histologically, the tumor is essentially a carcinoma containing elements of fibrosarcoma, that it is usually secondary to carcinoma elsewhere, especially to that of the stomach or intestines.

Ewing³ is inclined to believe that the pure Krukenberg tumor is always secondary, and that primary carcinoma presenting this structure regularly yields other areas of a different type of carcinoma.

In 1929, Fallas⁴ was able to collect twenty-three additional cases. A repetition of his summary regarding our knowledge of these tumors may help in a clearer understanding of the two cases to be reported. His conclusions were as follows:

(1) Krukenberg tumors are essentially a form of carcinoma identified by large mucinous cells often with eccentrically placed nuclei.

(2) They are almost, if not quite, invariably secondary to carcinoma elsewhere and usually to that in the gastro-intestinal tract.

(3) They metastasize early and are almost invariably fatal.

(4) They grow in a way to produce a general enlargement of the ovary which keeps its general form and is usually free of adhesions.

(5) Ascites is usually associated with the tumor.

In 1930, Enzer⁵ reported a case in a married woman, aged thirty-six, with bilateral ovarian tumors floating free in the abdominal cavity in a moderate quantity of clear ascetic fluid. A hard, indurated area was palpable in the stomach. The author brought the reported cases up to date, making a total of eighty-five.

In the same year, Tyner⁶ reported the case of a married woman, aged forty-eight, in whom the right ovary was involved with Krukenberg tumor and the left ovary was normal. The greater curvature of the stomach was the seat of an extensive carcinoma, and a gallon of clear ascitic fluid was present in the abdominal cavity.

Also, in 1930, Jackson and Babcock⁷ reported a case in a married colored woman, aged fifty. There was bloody fluid in the abdominal cavity with a markedly contracted

KRUKENBERG TUMOR OF THE OVARY

stomach containing a carcinoma of the Krukenberg type. Similar tumors were present in the left ovary and in the right mammary gland; the latter was large and discommoding and was the reason for which the patient sought surgical relief.

I have seen two cases of this condition. For the privilege of reporting the first case I am indebted to Dr. L. I. Breitstein and Dr. J. Schwarz, of San Francisco.

CASE I.—Mrs. R. F., multipara, aged thirty-four, was seen on July 29, 1922, complaining of pain in the lower abdomen and frequency of urination. The patient had lost forty pounds in the past three years and abdominal pain, chiefly over McBurney's point, had been present for the past six months.

Physical Examination revealed an abdominal tumor extending about eight centimetres above the symphysis; the mass was hard, somewhat irregular, and tender. Vaginally, the mass encroached on the vagina, filling the superior strait. The tumor resembled a fibroid of the uterus, and that was the pre-operative diagnosis.

Operation was performed on August 3, 1922. A moderate quantity of free ascitic fluid was present. The uterus was small and appeared normal. Tumors of both ovaries were found, the right ovarian mass was twisted on its pedicle, and was incarcerated in the pelvis. It was not adherent, was globular in shape, and measured about twelve by ten centimetres. The tumor of the left ovary was warty and hard, egg-shaped, and measured ten by eight centimetres. A bilateral oöphorectomy was performed. Examination of the gall-bladder and stomach was negative. Grossly the appendix seemed to be the seat of a malignant process and was not disturbed. Pathologic examination was made by Dr. G. Y. Rusk, of the University of California, San Francisco. Examination of the ovarian tumors revealed an essentially solid tissue type of growth with a honeycomb appearance on cross section. The microscopic sections showed the characteristic picture of Krukenberg tumor.

After consultation with the pathologist and röntgenologist, it was concluded that the appendix was the primary source of the malignancy and that it should be removed.

On August 16, 1922, the appendix, measuring 9.5 centimetres by 2.2 centimetres, was removed through a McBurney incision. It was grayish pink in color, with a firm and rather elastic consistency, and was bent at an acute angle near the middle. No definite lumen could be demonstrated on cross section. Microscopic examination revealed large, faintly staining, rounded cells with eccentrically placed nuclei; many of the cells had the signet-ring appearance. These cells were present in spaces encapsulated by loose strands of connective tissue and muscle.

The patient died two days following the second operation. The immediate cause of death was attributed to a rather advanced myocardial degeneration. Necropsy was not obtained.

CASE II.—The second patient, Mrs. I. J., Norwegian by birth, aged forty-five, had consulted Dr. Harold Brunn, of San Francisco, in September, 1915. At that time the patient was thirty years of age. She complained of nervousness and irregular menses. Physical examination was negative except for a moderately enlarged thyroid with a suspicion of exophthalmos and a secondary anæmia. The uterus was in second-degree retroflexion. The patient was given Bland's pills and ovarian extract, with resulting improvement.

She was not seen again until March, 1930. At this time her chief complaint was gas distress after eating, dating back to 1917. X-ray examinations made in 1917 revealed ptosis of the stomach for which the patient was treated, with resulting improvement. She had not been well for the past year and believed that her abdomen was growing larger but thought she had lost no weight. Her periods were regular, from three to four days in duration, but the flow was scanty. One sister had had a tumor of the stomach and another had a fibroid of the uterus.



FIG 1.—Anterior view of the large ovarian tumors attached to the uterus; the latter contains two small subserous fibroids in the region of the fundus. The insert shows the appearance of the ovarian tumor in cross section.

KRUKENBERG TUMOR OF THE OVARY

Physical Examination.—Blood-pressure 124/80. The patient was fairly well nourished and essentially normal except for her abdomen. A hard, nodular, movable tumor occupied most of the abdomen below the umbilicus. Considerable free fluid was present in the abdominal cavity. Vaginal examination revealed the tumor growth anterior to the uterus and probably not attached to it. The abdomen was opened on March 14, 1930. About three and a half liters of clear free fluid were present in the peritoneal cavity. The mass felt through the abdominal wall (Fig. 1) proved to be bilateral, solid ovarian tumors. They were not adherent and had not broken through the outer capsule of what once had been the ovary. No metastases were present in the gall-bladder, liver, or peritoneum except for a small nodule in the uterovesicle fold. The stomach was not palpated as we were unaware at the time that we were dealing with a Krukenberg tumor. The uterus contained several small fibroids. Bilateral salpingo-oöphorectomy, supra-vaginal hysterectomy, and appendectomy were done.

Microscopic examination by Doctor Rusk of sections from both ovarian tumor masses showed an invading new growth of abnormal epithelium growing in fine strands and clusters. In portions of the growth the epithelial cells occurred singly; these were

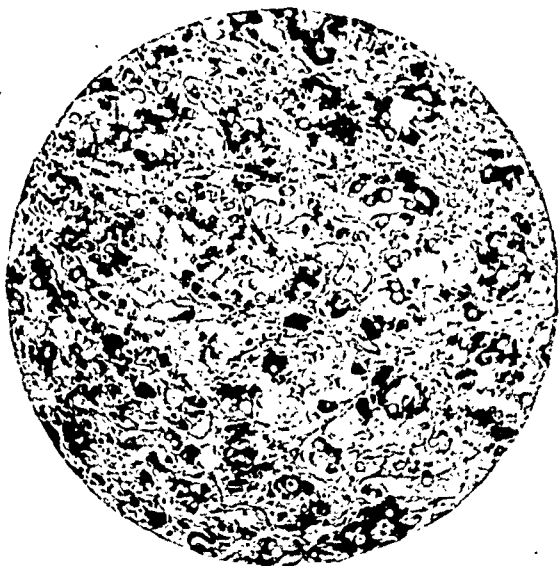


FIG. 2.—Low-power photomicrograph revealing the cells which typify the Krukenberg tumor.

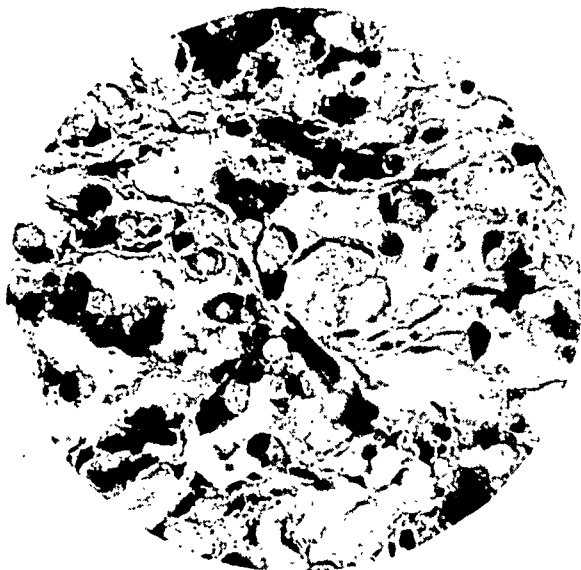


FIG. 3.—High power of Fig. 2. Several signet-ring cells appear in the field.

swollen, each contained a large droplet of mucus and gave the typical appearance of the Krukenberg tumor. (Figs. 2 and 3). Cells in mitotic division were rare. The uterine tumors were myomata. The nodule removed from the parietal peritoneum near the uterovesicle fold was found to be the seat of a moderate invasion with adeno-carcinomatous elements similar in character to those found in the ovary. The appendix was essentially negative.

During convalescence, the patient's stomach was investigated. There was no free hydrochloric acid and X-ray examination revealed a polypoid type of lesion in the greater curvature of the cardiac end of the stomach.

The patient did fairly well after operation but had several tarry stools; these continued after her discharge from the hospital and occasionally she vomited blood. Rather severe gastric hæmorrhages began about November 1, 1930, and continued until the patient's death on November 20. Necropsy was not permitted.

SUMMARY

(1) Two cases of Krukenberg tumor of the ovary are reported. These cases bear out the conception of the more recent writers that Krukenberg

tumors of the ovary are nearly always, if not invariably, secondary to carcinoma elsewhere and usually to that in the gastro-intestinal tract.

(2) In the first case, the growth was most likely primary in the appendix, but this cannot be determined definitely as there was no post-mortem. In the second case, the growth was in all likelihood primary in the stomach, but in this case also necropsy was not allowed.

(3) The total number of reported authentic cases is brought up to date, giving a total of eighty-nine including the two cases appearing in this communication.

(4) It is felt that if the summary of our knowledge of these tumors as outlined by Fallas is borne in mind, more of these growths will be recognized and diagnosed pre-operatively.

BIBLIOGRAPHY

- ¹ Krukenberg, Frederick E.: Ueber das Fibrosarcoma Ovarii Mucocellulare (Carcinomatodes). Arch. f. Gynaek, vol. 1, p. 287, 1895.
- ² Major, R. H.: Krukenberg Tumor. Surg., Gynec., and Obstet., vol. xxvii, p. 195, 1918.
- ³ Ewing, James: Neoplastic Disease. Third Edition, p. 647.
- ⁴ Fallas, Roy: Krukenberg Tumor of the Ovary. Surg., Gynec., and Obstet., vol. xlix, p. 638, 1929.
- ⁵ Enzer, N.: Krukenberg Tumors. ANNALS OF SURGERY, vol. xcii, pp. 149-152, July, 1930.
- ⁶ Tyner, J. D.: Krukenberg Tumor. Clifton M. Bull., vol. xvi, pp. 93-95, April, 1930.
- ⁷ Jackson, C., and Babcock, W. W.: Krukenberg Tumor. S. Clinics N. America, vol. x, pp. 271-272, December, 1930.

TREATMENT OF POTT'S FRACTURE

REPORT BASED ON FIFTY CASES

BY DAVID GOLDBLATT, M.D.

OF NEW YORK, N. Y.

FROM THE DEPARTMENT OF TRAUMATIC SURGERY OF THE NEW YORK POSTGRADUATE HOSPITAL

THE function of the ankle-joint, generally speaking, may be divided into two actions: a static, which maintains the posture and carries the weight of the body, and a dynamic, which institutes propulsion and regulates progression in the act of locomotion. These functions are made possible by the singular anatomical arrangement of the bones entering into the formation of this joint; the astragalus and lower ends of the tibia and fibula, creating a mortise, a relationship found nowhere else in the body, which allows the entire body to pivot on the astragalus as a fulcrum. Any injury which deranges this well-fitting mortise, disturbs the smoothly working pivotal action, producing a gyrating effect, with imbalance and falling. Further, the ankle-joint may be regarded as one of a pair of bases in the arch, in which the pelvis is the keystone, and the lower extremities are the abutments. Thus the whole weight of the body is equally divided and transmitted along the carrying angles of the lower extremities to be distributed *via* the ankles on to the feet. It is not surprising, then, to find that bony injury to so highly specialized a joint creates a disability which is immediate, complete, and compelling.

Besides this bony framework, the surrounding soft parts, synovial membrane, ligaments, tendons, cartilage, vascular and neural structures, and integument, the latter in close association with the bony landmarks, share in the injury, producing the arthro-teno-synovitis, that often requires more after-care than the actual fracture itself. The intimate contact of bone and skin in this region, with injury or irritation to the cutaneous nerves at the time of fracture of the bones, may explain the not uncommon associated large bleb formation in a badly comminuted fracture of the ankle or lower leg without contusion of the skin. Because of its architecture, fractures of this joint share with all intra-articular fractures in the possibility of being the most crippling, the most productive of deformity, and the most likely to leave a permanent disability.

It follows, therefore, that a complete functional restoration following an injury, such as Pott's fracture, in which the relationship of the bones of the ankle-joint is deranged, can only be brought about by perfect realignment of the anatomical landmarks of the joint structure. This is best accomplished by an early reduction. For an early reduction means an easy and good reduction, and a good reduction implies correct coaptation of fragments, which leads to good bony repair with minimal callus, precluding the

possibility of bony joint blockage due to irregular or exuberant callous formation. Repair here conforms to the axiomatic dictum that bony union invariably takes place in fractures within or near a joint, with the exception of fractures of the neck of the femur. But it also corroborates the well-known clinical experience that cartilage heals poorly and irregularly, so that injury to this tissue in association with bony injury may present the picture of dysfunction in spite of perfect reduction and alignment. This sequence of injury, recognition, reduction, retention, repair, and restoration of function operative here, as well as in all fractures, is the basis of our treatment.

In the present paper, an analysis of fifty consecutive, unselected cases of Pott's fracture is presented as a qualitative, rather than a numerical or quantitative study, because it is the writer's belief that a report of cases where personal contact is present in each case throughout the entire period of uniform treatment is more fertile in observations and experiences, and therefore more fruitful in conclusions, than a large number of cases under diversified management and treatment.

To obviate controversy, let it be understood from the outset, that, herein, a Pott's fracture will be regarded as one in which there is a fracture of the lower end of the fibula, associated with a tear of the internal lateral ligament or an avulsion of the tip or the entire internal malleolus with or without a lateral or posterior dislocation of the foot. This picture is often accompanied by a fracture of the medial or interosseous malleolus of the tibia, which may be missed upon the X-ray, unless trained to look for it; and requiring an oblique X-ray exposure of the ankle for demonstration. When present, this additional fragment of bone may act as a bony block in reduction, or interfere with maintenance of reduction, necessitating its removal. A modification of this, consisting in the splitting away of a wedge of bone from the posterior lip of the tibia, may act in a similar manner and require similar attention. Let it also be understood that treatment here, as in all fractures, is accorded upon a basis of typing fractures, into type I and type II. Type I comprising the displaced fractures, requiring reduction, and type II, the non-displaced fractures not requiring reduction. In both types, preliminary first aid in the form of a pillow splint or padded wooden splints applied from the knee to and including the foot, is given to put the broken parts at rest preventing increase of deformity and compounding. Compounding in a Pott's fracture often implies direct violence as the causative trauma, instead of the usual indirect violence responsible of the simple variety of this fracture. This situation, when present, is coped with in the early (six hours), or pre-incubation period of the contaminated organisms by mechanical sterilization which aims to expose the fracture site to vision, and excise all damaged and devitalized tissues, followed by primary suture with drainage. The safest procedure in converting a compound into a simple fracture, when seen later than six hours, is to resort to primo-secondary or delayed suture in which all steps except suture are taken, and the actual suturing is performed after the third day, when we are assured clinically

TREATMENT OF POTT'S FRACTURE

FIG. 1.—Lateral view showing posterior dislocation of foot.



FIG. 2.—Pott's fracture. Lateral view, showing anterior dislocation of foot. Ineffectual attempt at manual reduction.



and bacteriologically of the asepsis of the wound. An already infected fracture is a problem in osteomyelitis, and treated as such.

Inasmuch as, in the treatment of a displaced or type I fracture, we aim to convert it into a non-displaced or type II fracture by reduction, and thence the treatment is identical in both, a standardized form of treatment of the former variety of Pott's fracture will be described.

Reduction.—Manual reduction is carried out under anæsthesia, either general or spinal, to insure complete relaxation. For displacement of fragments is maintained and increased by muscular spasm, so that we really "set" a fracture by "setting" the muscles, in overcoming muscular spasm. With the thigh hyperflexed and the knee bent, to relax the calf group of muscles, an assistant "crooks" his elbow in the popliteal space pulling toward the head of the patient, as counter-traction. Where an assistant is not available, a muslin bandage or folded sheet, passed over a cotton pad in the popliteal space and tied to a fixed object at the head of the table, will suffice. The operator then grasps the heel and instep, applying slow and steady traction until a sense of "giving" is felt, then with the traction maintained, the foot is flexed (pushed upward) and inverted (pushed inward). This overcomes the backward and outward displacement and reestablishes the normal relationship of the mortise. The deformity has now been overcome and this corrected position is maintained by the assistant gently pulling toward the head of the table on a bandage tied to the great toe, while the knee is straightened, and until immobilization has been effected. Where force is needed to retain the foot at right-angled inversion, we may be reasonably sure that correction is incomplete, and that an everted foot will be the result. When the fragments are impacted, the ankle is manipulated in all directions until free crepitus or false motion is noted. This unlocks the fragments and of itself may effect reduction. In some cases an Achilles tenotomy is necessary to completely reduce the deformity. When reduction is contra-indicated because of the physique of the patient, or the application of splints is inadvisable because of the presence of infected blebs, skin-traction and suspension may be applied with knee bent, and foot dorsi-flexed and inverted, and the treatment carried along in this position.

Proofs of effected reduction are: (1) Restoration of relation of bony landmarks. Reestablishment of mortise. (2) Pressure on the sole of the foot by one finger keeps the ankle at right angles. (Jones's Test.) (3) Pressure upward on the sole of the foot does not reproduce deformity. (4) Reestablishment of the normal-carrying angles as manifested by the co-relation of the lower end of the tibia and upper surface of the astragalus, so that a line dropped down the middle of the front or side of the tibia, bisects the astragalus. This assures the normal pivotal action of the leg upon the astragalus, and *vice versa*.

Retention or immobilization is now instituted with the foot in right-angled inversion by means of plaster-of-Paris moulded splints of the Stimson variety, consisting of a posterior and internal lateral part, running from just

TREATMENT OF POTT'S FRACTURE

below the knee to and including the foot. After-care aims at an early restoration of articular activity. We know that in intra-articular fractures with hæmorrhage into the joint, fibrinous adhesions are formed, which at length become fibrous; and intra-articular fibrous bands may lead to bony ankylosis. Guarded early passive motion (after ten days) with guarded active motion soon to follow, causes the blood to be absorbed quickly and keeps the joint in a supple condition. To this end moulded plaster-of-Paris splints give access to both visual and tactile inspection of the injured parts, and to early application of massage. Part of the splint, the lateral, is removed when union is firm, at the end of twenty days, and the posterior splint is removed when union is solid and X-ray reveals callous formation, thirty to forty days. Walking about on crutches, but no weight-bearing, is allowed after one week.

In type II cases where reduction was early and the intra- and peri-articular damage is minimal, as estimated by the amount of swelling and X-ray findings, the patient is allowed up, in a plaster encasement with a walking iron attachment, after the acute or inflammatory stage subsides, when swelling has considerably or completely disappeared. Standing and walking with weight-bearing are permitted when pushing the foot hard against the floor produces no local reaction in terms of pain, swelling, or redness; and flat-foot precautions are instituted for a time by advising walking on the outer side of the foot with the toes in, and building up the inner side of the heel half an inch.

In fractures seen late with mal-union, open reduction is indicated.

STATISTICS

1. Males	36 cases	36 cases
Females	14 cases	14 cases
2. Age incidence		
Oldest case		70 years
Youngest case		19 years
3. Direct violence		23 cases
Indirect violence		27 cases
4. Right side involved		29 times
Right side involved		21 times
5. Displaced or type I cases		12 cases
Non-displaced or type II cases		38 cases
6. Compound fractures		3 cases
7. Associated lesions		
Fractured ribs		4 times
Colles' fracture		1 time
Skull fracture		1 time
8. Duration on admission		
Shortest time		1 hour
Longest time		2 weeks

TREATMENT

Non-operative

9. Moulded plaster-of-Paris splints	48 times
Plaster-of-Paris circular bandage	2 times

Operative

10. Immediate débridement.....	1 case
Skeletal traction.....	1 case
Open reduction.....	1 case
11. Duration of splintage	
Shortest time.....	21 days
Longest time.....	60 days
Average time.....	35 days
12. Time in bed	
Shortest time.....	1 day
Longest time.....	56 days
Average time.....	17 days
13. Time in hospital	
Shortest time.....	3 days
Longest time.....	60 days
Average time.....	21 days
14. Duration of physical therapy treatment	
Shortest time.....	4 weeks
Longest time.....	32 weeks
Average time.....	10 weeks
15. Total duration of treatment	
Shortest time.....	6 weeks
Longest time.....	40 weeks
Average time.....	10 weeks
16. Complications, osteomyelitis.....	1

In arriving at a functional result in Pott's fracture, the static and dynamic actions of the joint loom as the keynote in the desired triad in end-results, *viz.*, function, union, and contour. These are named in the order of their importance, and hence in the sequence of their desirability. Function or the capacity to perform being the most important, and here measured in terms of standing, and walking without pain or limping, is allotted a trifold numerical value, as compared to union and contour. Union or the state of repair, measured in terms of consistency, amount and distribution of callus, shares equally with contour and appearance, measured in terms of deformity, swelling and pes planus. This numerical ratio and mathematical grading of 60 per cent. for function, and 20 per cent. each for union and contour, though arbitrary, gives a uniform and standard valuation of end-results which, to our mind, is more satisfactory in producing a fixed basis of comparison, than the elastic terms of fair, good or perfect. End-results were obtained in twenty-three cases in this series, most of which were graded by at least two men and often three or more, and the average allotted to the individual case. No case was considered an end-result, any earlier than six months, this being considered sufficient time for a complete restoration of function, and is about twice the duration of the average total treatment. In this group there were seven females and sixteen males with four of the displaced or type I variety; and nineteen of the non-displaced or type II variety.

The average total for all the follow-up cases was 77 per cent.; divided into 47 per cent. for function, 16 per cent. for union and 14 per cent. for contour. The highest aggregate was 98 per cent.; divided into 60 per cent.

for function, 20 per cent. for union and 18 per cent. for contour. The lowest aggregate was 55 per cent.; divided into 30 per cent. for function, 14 per cent. for union and 11 per cent. for contour.

CONCLUSIONS

(1) This series would indicate that Pott's fracture is essentially an injury of adult life. The forces active in producing a Pott's fracture in an adult will produce an epiphyseal separation of the lower end of the tibia in a child.

(2) Judged by this series the ratio of incidence among males and females is approximately three to one.

(3) The automobile and modern industry as factors in injury are gaining in placing direct violence as a cause of this fracture, where indirect violence used to predominate.

(4) Displaced or type I fractures, in this region, require meticulous reduction and alignment to restore the highly specialized action of this joint, and prevent dysfunction that may follow poorly or irregularly healing cartilage, as a result of incorrect coaptation.

(5) Compounding with infection in the shaft of the bone is a regrettable occurrence; in a joint fracture it may become a tragedy. Hence, the importance of immediate attention. The ability to arrest infection being in indirect proportion to the duration of contamination.

(6) Where maintenance of reduction is a difficulty, one should be on the outlook for a fracture of the medial or interosseous malleolus of the tibia, or a tearing away of the posterior lip of this bone.

(7) The use of skeletal traction may then be necessary, and for that purpose a Kirschner pin or Steinman nail through the os calcis with or without a preliminary Achilles tenotomy are excellent adjuvants in the treatment of this complication. Where this fails, operative removal of the fragment is the choice.

(8) The use of moulded plaster-of-Paris splints instead of a circular encasement is a distinct advantage in the treatment of a Pott's fracture. It permits visual and tactile inspection of the fracture site, and promotes early passive activity.

(9) Physical therapy is an integral part of this treatment, and should be concomitant with, rather than subsequent to, immobilization. For a joint is as strong as its component muscles and tendons that mobilize it, and early restoration of muscle and tendon activity means lessened incapacity of the joint.

(10) Function may be consistent with deformity in a shaft fracture, but is decidedly inconsistent with a joint fracture.

(11) Old fractures of the ankle with malunion and ankylosis are a problem in joint plastics, requiring open correction and may prove disappointing.

(12) Non-union here is a rarity. When it does occur it speaks for interposition of soft parts, tendon, fascia or curled periosteum.

(13) Often under the best conditions, with the best of care, in frankly displaced or type I fractures, swelling and pain in the ankle will persist for a long time, as well as a widening of the joint, due to a tear of the lower tibio-fibular ligament.

(14) All the above statements would indicate that the treatment of Pott's fracture is by no means a closed chapter and that poor results will follow even in the hands of those specially trained to deal with these injuries.

(15) This series is presented as an attempt at standardization of fractures along the path of uniformity of classification (nomenclature), treatment (management), and grading (evaluation of end-results).

PROGRESSIVE POST-OPERATIVE CUTANEOUS GANGRENE

By HOWARD ALEXANDER PATTERSON, M.D.

OF NEW YORK, N.Y.

FROM THE FIRST SURGICAL DIVISION OF THE ROOSEVELT HOSPITAL

IN 1924, Cullen reported a case which presented a very extraordinary type of cutaneous gangrene,⁷ appearing in an incision made to drain an appendiceal abscess. His report was illustrated with water-color plates, and the condition was obviously—both in appearance and in its course—very different from any of the usual types of post-operative wound infection. Other men began to report similar experiences, most of the cases occurring in drained appendectomy incisions—but the total number of reported cases has remained small (approximately twenty), and one is justified in assuming that the condition is rare. While it is true that many cases have probably been observed and not reported, the comments of experienced consultants in regard to Cullen's case⁷ certainly support the belief that this type of complication is infrequently encountered.

Various terminologies have been used in attempting to apply an appropriate descriptive name to the condition, but a review of the reported cases leaves the very definite impression that all represent exactly the same process, probably due to the same etiological agencies, and form a definite clinical entity. Lynn recently expressed this opinion in a paper presented at the meeting of the American Medical Association, in Philadelphia.¹¹

In May, 1926, Dr. George Brewer read a report of two such cases before the American Surgical Association, in Detroit, and he subsequently reported⁸ elaborate bacteriological studies carried on by Meleney in an attempt to throw light on the etiology of this extraordinary complication. Meleney advanced the theory that the process was due to a sort of symbiosis indulged in by a certain strain of streptococcus and a staphylococcus, the former preferring little oxygen for its growth, and occurring in pure culture in the inflammatory zone beyond the margin of the advancing slough. The impression was based on animal experiments in addition to the clinical findings. More recently, Meleney has amply confirmed his earlier ideas in regard to this symbiosis of the strains involved—through additional clinical and experimental studies—and has presented his findings in more detail, along with a general discussion of bacterial synergism.¹³

Doctor Meleney was good enough to examine the patient that forms the basis of this report, and assures me that the clinical and bacteriological findings fall exactly in line with those of his own cases. It has seemed therefore appropriate to add another case report to the growing list.

CASE REPORT.—B. J., age sixty-two, was admitted to the Roosevelt Hospital June 29, 1930, complaining of abdominal pain of eighteen hours' duration. History and physical examination were quite typical of a fulminating acute appendicitis. Immediate operation

revealed an acutely inflamed appendix, with perforation at the base, and a rather extensive diffusing peritonitis. Following appendectomy with drainage his recovery was uneventful. The temperature reached normal on the sixth post-operative day, and remained so until his discharge, except for one reading of 100.4°. He was allowed home on the twenty-fourth day after operation with the wound entirely healed.

Following his return home he felt unusually well for two months, at which time he began to have a persistent hacking cough, which troubled him a great deal at night—and which shortly thereafter became productive, the sputum resembling thick tomato soup. For the next seven months his cough continued much the same. There was no loss of weight or strength, and no night sweats or fever. He remained at his work, and felt quite well apart from this annoying cough. During this time he was treated as an ambulatory case, and prolonged and various efforts were made to identify the pathology underlying the cough. Repeated blood Wassermann examinations were negative. No tubercle bacilli were found in the sputum. The sputum was centrifuged and sectioned, nothing being found in it to suggest neoplasm. Blood pressure was 168/78. The heart seemed slightly enlarged. Physical examination of the lungs revealed flatness at the right base below the angle of the scapula, with absent breath sounds. The physical findings over the remainder of the lung fields were normal.

Examination of the upper abdomen revealed no abnormal findings. X-ray examination showed a rounded shadow at the right base. It was difficult to be sure whether this was above or below the diaphragm, its outline being smooth and rounded. Bronchoscopy showed bloody sputum coming from a bronchus distributing to the right lower lobe posteriorly. Lipiodol instillation did not add any information. Further fluoroscopical studies increased the doubts as to the nature and location of the rounded shadow. Neoplasm was the favored diagnosis. Exploratory aspiration was done by Dr. Victor Lyman, and blood-stained pus was obtained from above the diaphragm—the material being quite similar to the sputum that the patient had been raising for so long. Culture showed a very small streptococcus that grew poorly in aerobic cultures. It grew better in sub-cultures, forming fairly long chains. No other organisms were found. The patient was referred for thoracotomy.

On April 1, 1931, two inches of the right tenth rib were removed under local anæsthesia, exposing a well-localized empyema cavity the size of a hen's egg, filled with the same "tomato soup" material that had been aspirated. A careful search revealed no evidence of the expected communication with a bronchiole. The small cavity was packed open, and one silkworm-gut suture was placed at the anterior angle of the incision. Following exposure and emptying of the cavity, no more sputum was raised, and the cough was immediately relieved. He was allowed to go home on the eleventh post-operative day, temperature having been normal for one week, and the wound being nearly healed.

Twenty-two days after the thoracotomy the patient was readmitted to the hospital on account of a slowly but surely progressing infection of the chest wall. This had first appeared in one of the silkworm-gut stitch-holes as a small furuncle-like spot. It enlarged slowly, progressing downward and forward, and never crossing the old incision, which had now healed. The patient felt well, temperature was normal, and he did not complain of pain unless disturbed. The involved area was, however, excruciatingly tender to the touch—a very striking feature. The advancing edge of the process was preceded by a wide, bluish, inflammatory zone. As this advanced, it left behind a tenacious gray slough resembling dirty felt. From beneath this many small beads of pus appeared on slight pressure. The slough involved only the skin and subcutaneous tissue, and the central part of the lesion, where the sloughing process was complete, presented a clean granulating surface. (Fig. 1.) Cultures from the sloughing area now yielded a hemolyzing staphylococcus, in addition to the very small micro-aërophilic streptococcus—apparently the same organism as that found in the material aspirated from the chest before operation.

POST-OPERATIVE CUTANEOUS GANGRENE

Various local treatments were of absolutely no use in halting the progress of the lesion. Removal of slough and local incisions (nitrous-oxide anæsthesia) did not improve matters. Hot poultices, Carrel-Dakin treatment, dilute iodine, dilute acetic acid, and even dilute formalin were tried without avail. The urine and the blood-sugar were normal. Blood Wassermann was negative.

On May 4, 1931, the margin of the large ulcerated area was excised with the actual cautery, under general anæsthesia. The excision was not carried outside the zone of redness, and there was a prompt recurrence of the process at two points in the periphery. Six days after the first excision, these two areas were excised widely. The condition gave us no further anxiety. Pain, redness, and tenderness did not recur. Thiersch grafts were applied to the granulating surface, and the entire area promptly epithelialized—with the aid of a small bud of epithelium that appeared unexpectedly in the middle of the granulating area—having survived the destructive process, probably in a deeply situated sweat-gland. The patient has since been symptom-free.



FIG. 1.—Showing the healed thoracotomy incision above and to the left. The central area presents a clean granulating surface.

Discussion.—The sequence of events in this case caused much speculation. It is probable that a pulmonary infarct was present when the patient left the hospital after the appendicectomy. Just why it should give no symptoms for months is difficult to understand. The infarct at the periphery of the right lung base finally broke down, and began to discharge through a small bronchus. The streptococcus was probably of intestinal origin. The area of the infarct became adherent to the parietal pleura and eventually formed, in effect, a small encapsulated empyema. Following drainage a local infection began in a stitch wound, and a cutaneous or air-borne staphylococcus joined with the streptococcus in producing the slowly progressing alarming gangrene that has been described above. Thus (as in most of these cases) the infection was of intestinal origin, although finally making its appearance in a thoracotomy wound.

The bacteriological findings corresponded to those of Meleney. A staphylococcus was found in association with an extremely small streptococcus, which grew poorly in aerobic cultures. In sub-cultures growth became more abundant. In the tissue excised at operation, the streptococcus was found in the outer zones where the lesion was extending, the staphylococcus being prominent in the areas where actual necrosis was present. On account of its preference for a low oxygen tension this particular strain of streptococcus belongs in the "micro-aërophilic" group. According to Meleney,¹³ it is probably correctly referred to as "streptococcus evolutus." The difficulty encountered in growing it probably accounts for the fact that it has not been demonstrated in some of the reported cases.

In Meleney's first cases³ a diphtheroid bacillus was found in addition to the two above-mentioned organisms. Subsequent clinical and experimental studies seem to indicate that this was an incidental finding. However, Mayeda¹² found somewhat similar organisms in his case, reported from the University Hospital in Tokio. It might be mentioned also that Homans' description⁹ of the appearance and behavior of the lesion in certain cases of "wound diphtheria" corresponds almost exactly to the clinical findings in these cases. Cole and Heideman⁶ demonstrated amœbæ both in smears and in sections from one of their cases of post-operative gangrene of the abdominal wall, but these findings have not been confirmed in subsequent cases in which they have been carefully sought for, and it is probable that the amœbæ were not the inciting cause of the process, but secondary invaders. The rare complication of gas-bacillus infection of the abdominal wall runs a rapid, extremely acute and characteristic course, and cannot be confused with the type of case we are discussing.^{4,15} In a great majority of the cases a streptococcus has been the prominent factor in the etiological study, and the micro-aërophilic character was striking in the cases of Christopher⁵ and Meleney¹³ and in our own case. It is probably true that this characteristic clinical entity results from the activity of a streptococcus of intestinal origin, the gangrenous process resulting from a symbiosis with a staphylococcus, either air-borne or of cutaneous origin.

In its clinical aspects, as well as bacteriologically, our case corresponded closely to those observed by Meleney. In fact, all the reported cases tend to conform to certain unusual characteristics which will be briefly outlined.

The appearance of this type of wound infection may be quite delayed. In our own case the patient had been allowed to go home and the process did not appear for two weeks following operation. In Brewer's first case the appearance of the wound was satisfactory for seven days after operation, and did not become alarming for ten.³ In his second case the wound infection was thought to be a very trivial one for a similar period. In the case reported by Cole and Heideman the appearance of the process was delayed even longer—eighteen days.⁶

The great majority of the patients who developed this complication had been operated on for suppurative appendicitis, but two cases in addition to

our own showed the process in thoracotomy incisions,^{5,2} and in one case the lesion appeared in an incision made to drain a breast abscess.¹⁴

The rate of spread of the process has been relatively slow in all cases. Alexander estimated that the gangrenous margin in his case advanced approximately four millimetres per day.¹ In spite of this relatively slow advance, the lesion—unless radical surgery interferes—may extend to phenomenal limits. The enormous destruction of tissue in some cases has made it necessary for the patient to be hospitalized for many months.^{14,1,16,5} In spite of this, eventual recovery is the rule. Only one case terminated fatally, and in that case acute nephritis was a contributing factor.⁸

The process remains, as a rule, quite superficial. In only one case did the deeper tissues become involved in the gangrenous process. In that case a large area of the abdominal musculature was destroyed, and Horsley was forced to resort to rather heroic measures to prevent evisceration.¹⁰ Certain other features of this particular case make it somewhat doubtful if it really belongs in the group under consideration.

The lesion itself has a unique and characteristic appearance. It usually appears in the small wound made by a tension suture, and this is an extremely important observation which has been made repeatedly.^{6,3,12} At first the infection may seem very trivial but as the area of involvement extends it becomes obvious that some unusual type of lesion is developing. The advancing margin is preceded by a wide bluish zone. The margin itself consists in a thin black rim which leaves behind a dirty, tenacious gray slough as it advances. As the slough separates, a clean granulating surface appears. Gentle pressure at the margin of the ulcer produces many small beads of pus which pop up from beneath the advancing edge. The lesion is extremely painful, far more so than the usual types of wound infection, and nitrous oxide may be required for the slightest handling. Conservative treatment has been uniformly useless in combating the process. The list of the various forms of local applications, radiation, *etc.*, that have been employed is a very long one.¹² It is a very justifiable tendency to wish to give conservative measures a fair trial, but in these cases radical measures must be resorted to promptly if long hospitalization, great scarring and prolonged pain are to be avoided.

Radical cure is effected by wide excision of the margins of the ulcerated area. This has usually been done with the actual cautery, but Meleney has demonstrated that the excision may be done with a scalpel, and carried well outside the zone of inflammation, without fear of starting the process anew. Inadequate excision will be followed by prompt recurrence, requiring a second excision. This happened in the case reported here, and others have had similar experiences.^{16,12} The use of Thiersch grafts will shorten the stay in the hospital, and lessen scarring. However, small islands of epithelium usually appear unexpectedly in the granulating area, having survived the gangrenous process in deeply situated sweat-glands.

I believe that it is extremely important, as a prophylactic measure, to avoid

the use of tension sutures in drained McBurney incisions and in thoracotomy incisions. They serve no useful purpose in these cases, and subject the patient to the danger of this rare but alarming complication. They do this by diminishing the blood supply to the skin alongside the wound, and by furnishing an ideal opportunity for micro-aërophilic organisms to gain a foothold in the subcutaneous tissue. They may produce a "stab-culture" in the subcutaneous tissue, such as we often use in the bacteriological laboratory in culturing such organisms.

CONCLUSIONS

An additional case is reported of progressive post-operative gangrene of the skin, of a type which represents a clinical entity. The lesion is unusual. It has a very characteristic appearance, bacteriology, and clinical course.

The bacteriological findings in this case corresponded closely to those of Meleney. The process is produced by the symbiotic activity of a very small variety of streptococcus that prefers a low oxygen tension, and a staphylococcus.

Although developing in a thoracotomy incision, the streptococcus in this case (as in most reported cases) was thought to be of intestinal origin.

Conservative measures are of no help whatever in dealing with this type of infection. The treatment of choice is early wide excision, either with cautery or scalpel. Adequate excision results in prompt cure.

The use of tension sutures in drained incisions predisposes to the development of this alarming complication.

BIBLIOGRAPHY

- ¹ Alexander, E. G.: Post-operative Spreading Superficial Gangrene. *ANNALS OF SURGERY*, vol. lxxxiv, p. 461, 1926.
- ² Ballin, M., and Morse, P. F.: Progressive Post-operative Gangrene of the Skin. *Amer. Journal of Surg.*, vol. xi, pp. 81-87, January, 1931.
- ³ Brewer, G. E., and Meleney, F. L.: Progressive Gangrenous Infection of the Skin and Subcutaneous Tissues, Following Operation for Acute Perforative Appendicitis. *ANNALS OF SURGERY*, vol. lxxxiv, pp. 438-450, September, 1926.
- ⁴ Butler, D. B.: *ANNALS OF SURGERY*, vol. lxxxiv, p. 841, 1926.
- ⁵ Christopher, F.: Severe Spreading Carbuncular Infection of Chest Wall Following Rib Resection Under Local Anæsthesia. *Surg. Clin. of No. Amer.*, vol. iv, pp. 795-810, June, 1924.
- ⁶ Cole, W. H., and Heideman, M. L.: Amoebic Ulcer of the Abdominal Wall Following Appendectomy with Drainage. *J.A.M.A.*, vol. xcii, pp. 537-540, February 16, 1929.
- ⁷ Cullen, Thos. F.: A Progressively Enlarging Ulcer of the Abdominal Wall Involving the Skin and Fat Following Drainage of an Abdominal Abscess Apparently of Appendiceal Origin. *Surg., Gynec. and Obstet.*, vol. xxxviii, pp. 579-582, May, 1924.
- ⁸ Freeman, L.: *ANNALS OF SURGERY*, vol. xcii, pp. 779-785, October, 1930.
- ⁹ Homans, John: Text-book of Surgery, p. 127, Baltimore, 1931.
- ¹⁰ Horsley, J. S.: *Archives of Surgery*, vol. xviii, pp. 882-891, March, 1929.
- ¹¹ Lynn, F. S.: Postoperative Gangrenous Ulcer of the Abdominal Wall. *Jour. A. M. A.*, vol. xcvii, pp. 1597-1602, November 28, 1931.
- ¹² Mayeda, Tomosuke: Eine Seltsame Hautgeschwursbildung nach der Appendektomie. *Deutsche Ztschr. f. Chir.*, vol. cxcix, p. 350, 1926.

POST-OPERATIVE CUTANEOUS GANGRENE

- ¹³ Meleney, F. L.: Bacterial Synergism in Disease Processes. ANNALS OF SURGERY, vol. xciv, pp. 961-981, December, 1931.
- ¹⁴ Probstein, J. G., and Seelig, M. G.: The Treatment of Post-operative Gangrenous Infection of the Skin and Subcutaneous Tissue with Blood from Immunized Donors. Surg. Gynec. and Obstet., vol. xlvii, pp. 247-251, August, 1928.
- ¹⁵ Shearer, J. P.: ANNALS OF SURGERY, vol. xc, pp. 1114-1117, December, 1929.
- ¹⁶ Shipley, A. M.: Progressive Gangrenous Ulceration of the Abdominal Wall. ANNALS OF SURGERY, vol. lxxxvii, p. 245, February, 1928.

TRANSACTIONS AMERICAN SURGICAL ASSOCIATION

MEETING HELD MAY 16, 17 AND 18, 1932; *Continued*

RADICAL OPERATIONS FOR CARCINOMA OF THE BREAST

A PRELIMINARY EXCISION OF THE TUMOR OR ABLATION OF THE BREAST

BY CARL EGGERS, M.D.

OF NEW YORK, N. Y.

THE standards by means of which we may judge the success of an operation for carcinoma of the breast are the local cure of the disease, the avoidance of regional and distant metastases, and longevity. Only in so far as the factors concerned in the treatment are under a surgeon's control can he be held responsible for them.

By local cure is meant having the patient live without any sign of recurrence within the operative field, either in the scar, the skin, or the subcutaneous tissue. The appearance of a carcinoma at any time after a radical operation in the scar, the skin in the neighborhood of the scar, in the subcutaneous tissue of this same region, on the outer chest wall, or in the axilla, is classed as a recurrence.

Regional metastases are those secondary growths resulting from direct drainage of the operative field. They are probably all due to extensions along the lymphatic vessels. Supraclavicular and mediastinal lymph-node metastases belong to this group. Metastatic tumors situated in the chest wall probably are also metastatic in character and arise along the lymphatics accompanying the anterior perforating branches of the internal mammary artery. Perhaps secondary tumors in the opposite breast may be classed as regional metastases.

Distant metastases are those occurring in the osseous system and in internal organs at some distance from the operative field.

Longevity may depend on any of these factors but may be entirely independent of them and be influenced by the general condition of the patient or by intercurrent disease.

It has been customary to hold a surgeon responsible for local recurrences, for it has been felt and has been shown by experience that in properly performed radical operations they are rare. Metastases, on the other hand, both regional and distant, have been considered beyond a surgeon's control, and their prevention has apparently not received the amount of attention it deserves.

Various statistical reports dealing with the late results after operation for carcinoma of the breast make one feel that no real progress is being

made. We are at a standstill and a feeling of pessimism regarding the entire subject may be noted. Perhaps the best reports come from those clinics combining radical surgery with post-operative radiation. It is difficult to place the proper value on some of the published statistics. One does not always know whether patients were selected for operation or whether all patients in whom the tumor was removable are included. In the same way pathological classifications vary and border-line cases are at times included.

Ever since the radical operation was proposed by Halstead and Willy Meyer, attempts have been made to improve on the results first published, either by variations of the technical procedure or by the addition of pre- or post-operative radiation, or both. There have been and still are disputes concerning the necessity for the removal of a large area of skin, whether one or both pectoral muscles should be sacrificed, whether it is necessary to remove the fascia over the rectus muscle, *etc.* Much stress is laid by some authors on the type of incision, the amount of muscle and fascia excised, whether the skin is thoroughly undermined, thereby insuring the removal of a large quantity of subcutaneous fat, the importance of remaining outside the fascial sheath in the axillary dissection and never crossing the planes of possible cancer extension, and the need for removing the vessel sheath. These considerations are all of importance but none of them has advanced us materially. The results as far as can be judged are not much better than they originally were. The question regarding the value of pre- or post-operative radiation, or both, has not yet been settled. A study of the literature would lead one to believe that real advance along this line is possible. The danger is that radiation enthusiasts are often satisfied with an incomplete operation and depend on their treatment to destroy cancer cells which have been left behind. It would seem that a real radical operation followed by radiation over those areas along which cancer spread may be expected by the location of the tumor may help materially in improving our results.

Studying carcinoma recurrences or metastases from the standpoint of location may help us some in determining whether anything further can be done.

At the Lenox Hill Hospital we perform a very radical operation, we use meticulous care in the dissection and take ample time. The operation consists of:

- (1) Removal of the breast with an adequate skin margin well beyond the tumor.
- (2) Thorough undermining of the skin margins which insures extensive removal of the subcutaneous tissue with the breast, and aids in closing.
- (3) Excision of the entire pectoralis major and minor.
- (4) Removal of the entire axillary contents taking care to include the lymph-nodes in front of the scapula and those situated high in the axilla above the vessels.
- (5) Thorough clean dissection of the chest wall.
- (6) Skin graft when indicated.

The incision is varied somewhat depending on the position of the tumor.

With this technic we have found that

- (1) Local recurrences are very rare.
- (2) Axillary recurrences are almost unknown.
- (3) Chest-wall tumors (intercostal, probably regional metastatic) are rare.

We have recognized that the operation as carried out is adequate to prevent recurrences. Any change in technic, therefore, would be simply aimed at improving the appearance of the scar. The functional results are perfect. Occasionally there is oedema of the arm, but very rarely of a disabling nature.

In spite of these favorable local results the death rate from late cancer of the breast is high at our hospital, as well as at other institutions. The patients die from metastases, not from recurrences. How and when are these metastases spread, and can anything be done to prevent their dissemination? The answer to this will determine whether there is going to be much improvement in our surgical results.

Any group study of patients with metastases following a radical breast operation will show a large percentage with intrathoracic involvement, either of the lungs, the pleura, or the mediastinal lymph-nodes. There are also intra-abdominal cases and a very large number of patients with metastases in the osseous system. Almost any organ may be involved. Frequently there is an isolated metastasis in a bone far removed from the field of operation. Carcinoma is usually believed to spread by way of the lymphatics, and many metastases can be explained on that theory. On the other hand, tumor emboli are frequently found in blood-vessels and it is conceivable that tumor cells enter the blood-stream directly in that way, rather than indirectly by way of the lymphatic circulation. Distant isolated metastases, especially those of the osseous system, are more easily explained on the theory of having been carried there by the blood-stream than by the lymphatics.

Depending on the location of the tumor within the breast, the lymphatic spread may be chiefly towards the axillary lymph-nodes, or along the lymph channels accompanying the penetrating blood-vessels of the anterior chest wall to the lymph-nodes of the mediastinum, or along any of the lymph channels crossing over to the opposite side or passing downward. The blood-stream spread may follow along these same general lines.

In trying to attain the best possible results it seems imperative to consider all these different paths and to take steps to prevent the dissemination of cancer cells beyond the accessible area.

We do this today by making an incision well beyond the tumor and in addition to the breast taking along a wide margin of skin and subcutaneous tissue, both pectoral muscles, the entire axillary contents with all fascial layers, and a meticulous dissection of the chest wall. Those who believe in the existence of lymphatic channels in the rectus sheath connecting with the liver also take away this sheath. As far as operative intervention is concerned, this is about all one can do. The only other accessible areas which

could be attacked surgically would be the supraclavicular region and the opposite breast. The comparative infrequency of supraclavicular involvement or of invasion of the opposite breast makes the removal of these organs as routine procedures inadvisable. The extensions along the perforating vessels into the mediastinum are inaccessible, or at least it is not justified to resect costal cartilages merely on the supposition that involved nodes may be situated along the internal mammary vessels.

The radical operation as practiced today contemplates the removal of all those tissues which may have been directly invaded by the tumor, as well as all the lymphatic vessels leading away from it, as far as they are accessible. Only in the direction toward the axilla does it include the system of lymph-nodes which drain the breast. Unfortunately, many tumors are situated within the breast at a place which drains into the mediastinum rather than towards the axilla. It is apparent, therefore, that the operation does not adequately guard against the spread along the perforating vessels, and it does not at all guard against spreading cancer cells by the blood-stream.

The question arises: Is it within our power to do anything to guard against the spread of cancer cells leading to metastases? To answer this we must consider the question of how and when cancer cells are spread. Taking an isolated bone metastasis, for instance, one may safely say that in the absence of local recurrences or regional metastases, it must have been carried there directly from the tumor either before or during the operation. Metastases which have developed or are in the process of developing before the patient comes under observation are evidently beyond a surgeon's control and he is not responsible for them. On the other hand, after the surgeon has seen the patient, he may be responsible for the spread of cancer cells by injudicious manipulation of the growth. Emphasizing this point rather strongly one may say that there is a possibility of improving our results by attention to this point. Rough handling of the breast and pressure on the tumor, or over the involved axillary lymph-nodes, may easily force cells into the lymphatic vessels or into the blood-stream. To avoid this it is very important to refrain from frequent and especially from rough handling of the breast and axillary contents by either the patient or the physician before operation.

I also want to call attention to the rough handling to which a breast is subjected during the operation. It is forcibly drawn over to the opposite side during the axillary dissection and there are any number of opportunities for cancer cells to become dislodged and carried into the circulation. To avoid this I have for several years changed my method of procedure, and made it a practice to either excise the tumor or do an ablation before proceeding with the radical operation. In all doubtful cases, and in clinically positive carcinoma cases in which the tumor is single and easily removable, I do an excision with a good margin of normal tissue, await the report on the frozen section, and if positive, proceed with the radical operation. The breast can be held by an assistant in such a way that no pressure is made on

the tumor. In all extensive carcinoma cases, and in those with multiple or ulcerating tumors, I do a rapid ablation without much handling and then immediately follow with the radical procedure.

Personal observation and a discussion of this subject with some of my colleagues have convinced me that patients in whom a preliminary excision of the tumor was done have not suffered as a result of this, but that on the contrary it seems to offer a way to reduce the number of patients developing metastases.

The only other way of controlling metastases seems to lie in radiation therapy. It is conceivable that pre-operative radiation may fix cancer cells by producing a fibrosis and thus make their spread less likely during operation. The combined treatment by surgery and radium implantations at the time of operation looks promising and deserves attention. Post-operative radiation over those areas most likely to become affected by drainage from the original cancer can do no harm and should be employed in selected cases, especially in those in whom the tumor was situated near the median line with probable extension into the mediastinal lymph-nodes.

The question of biopsy in breast cancer has long been a disputed one. Is it safe to do one or should the practice be condemned? To answer this one has to have a clear understanding of what is meant by a biopsy. If it is incision into the tumor with excision of a small piece for diagnosis, the practice is to be condemned as it opens up paths for spreading cancer cells. On the other hand, if it is complete excision of the tumor with a little surrounding normal tissue, it is a perfectly safe procedure, and is in line with the treatment of breast cancer advocated in this paper.

TRAUMATIC LESIONS OF ARTERIES: INDICATIONS FOR THERAPEUTIC LIGATION OF VEINS

BY JOHN DEJ. PEMBERTON, M.D.

AND

JOHN M. McCAUGHAN, M.D.

OF ROCHESTER, MINN.

LIGATION of the accompanying vein in the course of ligation of large arteries was, before advocacy of this procedure by Makins, in 1917, almost never performed, except as a matter of dire necessity. It had been taught by surgeons of an earlier day that occlusion of the vein, in cases in which ligature of the large arteries of the extremities was required, would increase the risks of gangrene.

Although it is true that Oppel, in 1913, recommended ligation of the popliteal vein for treatment of senile gangrene of the foot, and that Sehrt, in 1916, urged its consideration on the grounds that ligation of the vein would prevent too rapid emptying of venous blood from the injured extremity, it was really the statistical work of Makins based on his experience with gunshot wounds in the South African war and in the World War that made generally accepted the principle of elective ligation of satellite veins. Makins, in comparing the results in a large series of cases in which only the artery of an extremity was ligated with a similar group in which both the arteries and veins were ligated, showed that simultaneous ligation of the accompanying vein actually reduced the incidence of gangrene. Prior to Makins' work, however, others had reported favorable results following this procedure, notably Zondek, Bernheim and Worth, Griebel, and Boeckel.

This measure, nevertheless, has been subject to some criticism. Halsted was not convinced that under ideal aseptic conditions gangrene was a frequent complication of ligation of large arteries, and stated that he was disinclined to tie off simultaneously the corresponding vein until evidence of ischæmia developed, because he felt that such a manœuvre would tend to delay the development of collateral circulation. Recently, Mulvihill, Harvey and Doroszka, in an experimental investigation of this problem, ligated the external iliac artery and vein of seven dogs. They concluded that ligation of the vein had no demonstrable effect in aiding or retarding development of collateral circulation, as shown by the curves of temperature obtained from the periphery of the extremity.

More recently, Montgomery, in a series of experiments on dogs, found that after ligation of the superficial femoral artery, ligation of its concomitant vein caused either no change or a slight decrease in the per minute volume flow of blood and a more marked decrease when the venous return was obstructed proximal to the site of arterial occlusion. He concluded that

ligation of the concomitant vein should be avoided in treatment of acute obstructions of the main arterial supply, unless the obstruction was in the popliteal artery, in which case the procedure is strongly supported by clinical data. He is of the opinion that it is wiser to await the appearance of impending gangrene before ligating the vein.

The clinical and experimental investigations of a substantial number of other workers, namely, Van Kend, Tuffier, Propping, Makins, LaRoque, Heitz, Brooks and Martin, Harvey and Ferris, McNealy, Holman and Edwards, Theis, and Pearse, provided much evidence to support the view that ligation of the corresponding vein is of definite value.

Although there is some controversy as to the manner in which this benefit is effected, we believe, with Brooks and Martin, that occlusion of the vein simultaneously with the artery results in greater intravascular pressure, although in a slightly smaller flow of blood, and that this increase in intravascular pressure forces blood into the distal capillary beds and serves to prevent complete collapse of the capillaries in the distal parts, and that this, in turn, results in more homogeneous distribution of the available blood. The more recent researches of Brooks and Johnson on distribution of the flow of peripheral blood in the dog are of particular interest. They employed a special apparatus for perfusion by which their material was kept at constant temperature, and the variation in temperature at different levels in the posterior extremity was taken as an index of the degree of distribution of the perfusion fluid. According to these experimenters, regulation of the flow of peripheral blood is extremely complex, depending on nervous, hormonal, and purely mechanical factors. They noted that experiments with the perfusion pump gave much the same results as experiments with living animals, as far as being able to influence distribution of blood is concerned. They stated: "The blood flow was unequally distributed, and this distribution could not be appreciably changed by any method used." Nevertheless, from their observations on the effect of increasing venous pressure, they concluded: "Usually increasing venous pressure did appreciably change the distribution of the blood flow in the perfusion experiments. In some instances it seemed possible, so to speak, to open a portion of the vascular bed for circulation by increasing venous pressure."

From our clinical experience, and that of others, we are of the opinion that simultaneous ligation of the concomitant vein is of definite value in selected cases. That this procedure may be inadvisable under certain conditions was first recognized by Brooks, in 1923. In a later article he stated: "It would seem, therefore, as if the remote effects of therapeutic venous obstruction must be taken into consideration. In other words, ligation of a vein might be the means of averting gangrene, but the cause of subsequent chronic venous stasis. The clinical experience available is not sufficient for drawing definite conclusions."

Reference to the literature reveals no very adequate clinical criterion to aid the surgeon in determining in a given case whether the vein should be occluded. Even

Makins was uncertain, for in a letter to Brooks in 1922, he stated: "I have seen some swollen extremities and varicose veins amongst the war pensioners, but in all cases I have had the opportunity of examining, the injury to the vessels was accompanied either by very extensive wounds with loss of substance, or fracture of the femur or pelvis. I have not been able to regard these cases as a fair test, and no uncomplicated case of ligation of artery and vein with unsatisfactory after-consequences has come under my notice. Still, I think the question of the ultimate condition of the limb must be considered undecided." We have reviewed the pertinent clinical literature which has appeared on this subject since the publication of Makins' work, and in no instance have we been able to find a clear-cut definition of either the indications for, or contra-indications to, this procedure. Propping, for example, recommended ligation of the vein in cases in which gangrene may be expected. LaRoque wrote: "There is genuine reason for believing that vein ligation favors the development of collateral vessels, and through retention of blood volume and pressure aids enlargement of vessels already present." McNealy, writing on elective ligation of veins in surgery of blood-vessels, stated: "Simultaneous vein ligation must be so selected that it will serve only to restore circulatory equilibrium and must not result in too great a damming back of blood, lest ill effects of passive congestion outweigh the beneficial effects of increased capillary pressure. Here again Bier has pointed out that venous blood does become a source of trouble when the passive congestion exists over a long period and the venous blood becomes surcharged with tissue poisons. Knowing the good effects which may be expected to follow vein ligation, one must also bear in mind that there is a certain lethal limit in the tidal flow of blood to an extremity or tissue."

Holman and Edwards, in 1927, advocated ligation of the vein proximal to the site of ligation of the artery. In the same year, Holman stated: "The circumstances demanding the ligation of the vein proximal to arterial ligation would presumably be dependent upon the extent to which collateral circulation had already developed as the result of the lesion which necessitated the ligation. Proximal ligation of the vein would be applicable in all cases which entailed an acute shutting off of the arterial supply, as in traumatic injury to vessels. If for any reason a collateral circulation had already developed, its application would probably be less imperative and perhaps accompanied by a certain degree of danger of swelling in the limb."

Theis gave his views on elective ligation of the concomitant vein in the following words: "With sudden occlusion of a large artery, as in embolism or injury to the vessel, the immediate improvement in the collateral bed due to ligation of the concomitant vein is needed to maintain the vitality of the limb. When a certain amount of collateral vessels have had an opportunity to develop, as in threatened spontaneous gangrene, surgical procedures on the main vessels of the extremities should be limited to the artery alone."

A great deal of generalizing but little information of practical value is found. As a general summary of the problem, the following statement by Brooks is significant: "Simultaneous ligation of the vein is not to be considered the preferable procedure in all arterial ligations. It is to be applied only in those instances in which without ligation of the vein gangrene would be expected. In these instances, the probably immediate beneficial effects in preventing gangrene must be balanced with the possible remote ill effects of chronic venous stasis."

There is, of course, abundant clinical evidence to support the admonition of Brooks against indiscriminate ligation of the concomitant vein in all cases of obstruction of the artery. In the first place, statistics gathered from practice both in war and in civil life show that when only the main artery of an extremity is obstructed, in only a relatively small percentage of cases does gangrene ensue, requiring amputation of the extremity. This per-

centage is variable, apparently depending on many factors, chief of which are the following: The site of obstruction of the artery; the extent of associated trauma to the contiguous tissues; the presence or absence of infection; the mode of onset of arterial obstruction, that is, whether sudden or progressive, and the employment of or lack of preliminary measures, in cases of contemplated surgical ligation, to stimulate development of collateral circulation. In the second place, not infrequently the venous stasis induced by simultaneous ligation of the concomitant vein results in protracted œdema and swelling of the extremity, in some instances persisting as permanent disability.

The desirability of avoiding this latter complication is obvious, and therefore, before any step is undertaken to obstruct the principal venous channel, careful consideration should always be given, not only to the need of such a procedure as an aid in maintaining circulation in the extremity, but also to the risk of development of troublesome venous stasis. On the other hand, there are ample clinical and experimental data to indicate that in some cases of arterial obstruction, ligation of the concomitant vein may be a valuable procedure in reducing the incidence of gangrene, and furthermore, there is sufficient clinical evidence to show that, in selected cases of arterial obstruction, ligation of the satellite vein apparently has been the means of maintaining adequate circulation to the extremity without, at the same time, producing any of the evil effects of venous stasis. In one of our cases of obstructive aneurism of the common femoral artery, with beginning gangrene of the toes, ligation of the femoral vein restored adequate circulation to the extremity without producing swelling and œdema.

It is evident, therefore, that therapeutic ligation of the concomitant vein is indicated in certain cases of arterial obstruction, whereas it is contra-indicated in others. Maintenance of adequate supply of blood to the tissues distal to the point of obstruction of the artery is obviously dependent on efficiency of the collateral circulation. As is known from anatomical dissection, there is considerable variation in the development of the collateral arterial tree in different subjects and in the same subjects in different regions of the body. From the clinical standpoint, the variation in the incidence of gangrene of the extremity following ligation of the artery under almost identical conditions also indicates variability in the efficiency of collateral circulation of different patients. It is obvious, then, that in arterial obstruction surgical treatment should vary according to adequacy of the collateral circulation. When the collateral circulation is inadequate, ligation of the accompanying vein, as a means of aiding circulation to the extremity, is definitely indicated. However, when the collateral circulation is adequate it is obvious that venous occlusion is not only not indicated, but is definitely contra-indicated on account of the risk of producing imbalance of the circulation.

Clinical criteria exist by which the surgeon can at the time of the operation determine whether simultaneous ligation of the vein should be done. Since 1918, one of us (Pemberton) at the suggestion of C. H. Mayo, has

been employing a simple and apparently accurate clinical test; previously, in 1912, this test (Fig. 1) had also been described in the literature by Henle and his assistant Stoltz, and again independently by Coenen. The test depends on observation, during the operation of the exposed arterial segments, both proximal and distal to the lesion. If a retrograde flow of blood is obtained from the opened end of the distal arterial segment, while the proximal portion is being compressed with a clamp, it is taken as an indication of adequate collateral circulation. The Quénu-Muret sign, described in 1910, is similar, and depends on the detection of bleeding from any portion of the peripheral arterial tree after puncture or incision, when the main trunk of the limb is being compressed. Naturally, such a procedure is objectionable. Matas reviewed the merits of the various methods which had been

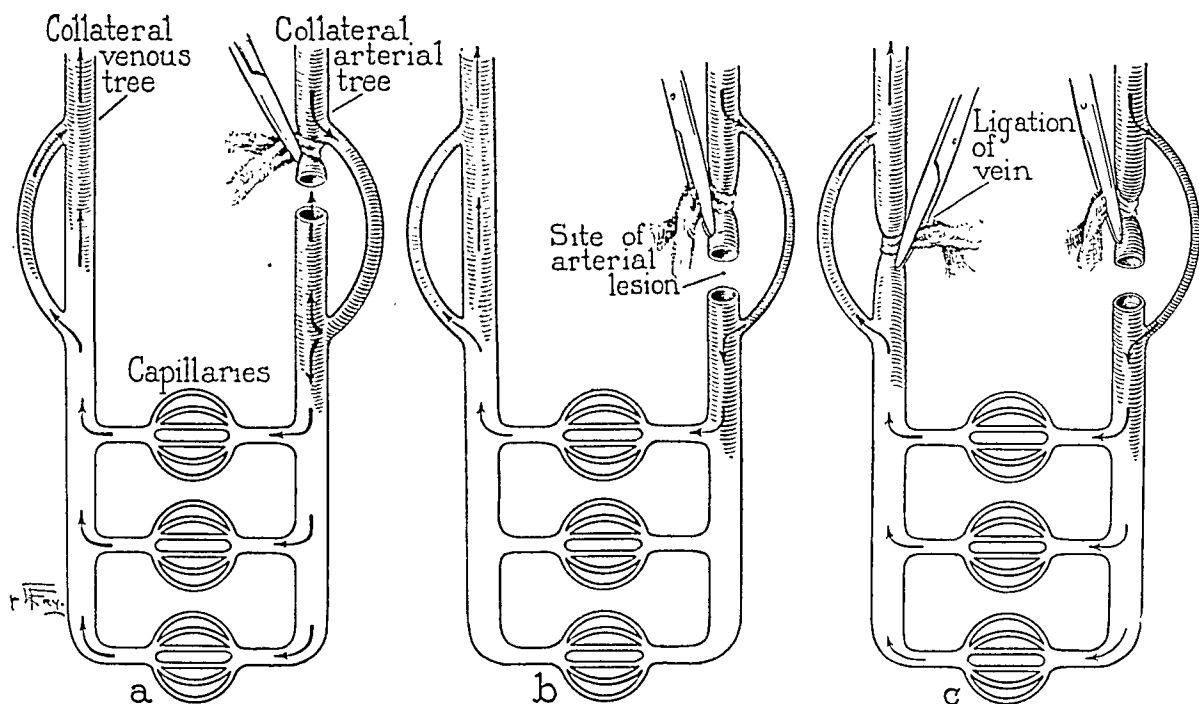


FIG. 1.—Mechanism of the Henle-Coenen test: (a) Retrograde flow from, or pulsations in artery on distal side of lesion with proximal side occluded, denotes positive Henle-Coenen sign and indicates adequate collateral circulation. (b) No retrograde flow from, or no pulsation in artery on distal side of lesion, with proximal side occluded, denotes negative Henle-Coenen sign and indicates inadequate collateral circulation. Blood fails to reach distal capillary bed. (c) Occlusion of main accompanying vein induces more equal distribution of blood throughout capillary bed.

proposed for testing collateral circulation, including the Henle-Coenen sign, which he regarded as “fallacious and liable to erroneous interpretation.” He admitted, however, that it is of value in dealing with emergencies concerned with wounded, bleeding arteries, when used in conjunction with the other two signs of the Von Frisch test; namely, a normal or approximately normal coloration of the peripheral parts when the proximal side of the injured vessel is compressed, and the appearance of venous stasis on the peripheral side of the temporarily occluded main vein, the artery proximal to the lesion, of course, being compressed meanwhile.

As regards the Henle-Coenen test alone, there is considerable clinical evidence to show that peripheral gangrene is a rare complication when a positive Henle-Coenen sign has been obtained. Table I is an analysis of fifteen of

TABLE I
Data Concerning Fifteen Cases in Which the Henle-Coenen Sign Was Recorded

Case	Age (Yrs.), Sex	Indications for Ligation	Circulatory Efficiency before Operation	Date of Operation	Type of Operation	Henle-Coenen Sign	Results	Comment
1	30 F.	Accidental injury to right external iliac artery	Apparently normal to routine physical examination	12-15-17	Ligation of right external iliac artery	Positive	Dismissed 1-10-28; excellent condition	Arterial injury during course of external Alexander operation
2	57 M.	Spontaneous aneurism of left popliteal artery; syphilis	Adequate	1-5-20	Left popliteal artery ligated, and Matas obliterative endo-aneurismorrhaphy	Positive	Dismissed 2-27-20; complete recovery; circulation adequate	
3	39 M.	Traumatic aneurism of left thigh, arteriovenous varix (?)	Poor; ulceration left leg; venous stasis; no pulsations dorsalis pedis and posterior tibial arteries	12-1-19	Left common femoral artery ligated and arteriovenous fistula (?) ligated	Positive		
		Returned 10-28-25; ulceration of left leg, diagnosed arteriovenous aneurism left femoral vessels	Same	11-11-25	Excision of arteriovenous aneurism from left femoral vessels			
		Returned 2-4-26 with mass in left side behind peritoneum	Same	2-8-26	Removal of segment of aneurismal sac from region of left external iliac artery		Dismissed 4-28-26; persistence of pain, swelling and ulceration in left leg	2-1-30 patient still complained of swelling, pain and ulceration of left leg
4	40 M.	Accidental injury to left external iliac artery	Apparently adequate on routinely made physical examination	6-30-21	Exploration of tumor of left ureter; ligation of left external iliac artery	Positive	Given Röntgen treatment and dismissed 7-26-21; circulation in extremity satisfactory	3-21-29 patient in good health
5	46 F.	Spontaneous aneurism of left popliteal artery; Wassermann test negative	Adequate, although pulsation of dorsalis pedis absent	11-9-25	Obliterative endo-aneurismorrhaphy and ligation of popliteal artery and vein	Positive (?)	Dismissed 1-3-26; pain and swelling in leg and left foot drop; very slight retrograde bleeding	3-26-26 same complaint of pain and swelling in leg
6	33 M.	Traumatic aneurism of right femoral artery	Adequate, but considerable swelling in extremity	8-14-25	Femoral artery ligated; femoral vein probably also ligated	Positive	Dismissed 9-21-25; complete recovery	4-18-27 patient able to work
7	40 M.	Left femoral aneurism, ruptured (traumatic?)	Adequate	10-1-25	Left superficial femoral artery ligated; obliterative endo-aneurismorrhaphy	Positive	Dismissed 1-29-26; complete recovery	

TRAUMATIC LESIONS OF ARTERIES

8	44 M.	Bilateral popliteal aneurism accompanying Buerger's disease	Matas test indicated adequate circulation	12- 4-25	Obliterative; endo-aneurismorrhaphy of left popliteal artery	Negative	Circulation adequate although vessels of foot could not be palpated	10-30 no recurrence of aneurism: still complained of symptoms of thrombo-angitis obliterans
9	21 M.	Spontaneous left femoral aneurism developed during convalescence	Adequate by Matas test; intermittent compression employed	1- 6-26	Same operation right popliteal artery	Positive	3-1-26 dismissed in good condition	No arterial symptoms but recurring superficial-phlebitis
10	12 M.	Traumatic aneurism (?) left femoral artery	Adequate; intermittent compression used	2-20-32	Ligation of femoral artery	Positive	Dismissed 5-11-32; completely recovered	
11	63 M.	Aneurism of right superficial femoral artery, traumatic	Adequate	7- 4-28	Obliterative endo-aneurismorrhaphy of right superficial femoral artery	Positive	Dismissed 7-20-28; completely recovered	
12	8 M.	Spontaneous aneurism right common femoral artery; Wassermann test negative	Inadequate; ischæmia with threatening gangrene	2-11-31	Obliterative endo-aneurismorrhaphy; ligation of femoral artery, elective ligation of femoral vein	Negative	Dismissed 7-20-31; completely recovered	Circulation improved greatly with ligation of concomitant vein
13	47 F.	Stab-wound in right thigh; severe hæmorrhage followed later by ischæmia; beginning gangrene	Poor; extremity swollen, painful, tender, cool; no peripheral pulsations	6-23-31	Right deep femoral artery ligated	Positive	Dismissed 7-27-31; complete recovery	
14	40 M.	Spontaneous aneurism right brachial artery; Wassermann test negative	Adequate; intermittent compression used	8-19-31	Proximal and distal ligation and obliterative endo-aneurismorrhaphy of right brachial artery; elective ligation of brachial vein	Positive (?)	Dismissed 8-31-31; circulation good; radial pulse absent; no swelling	No pulsations of distal artery at operation, but sac filled with proximal artery clamped
15	60 F.	Left subclavian hematoma, traumatic	Inadequate; swelling, pain, cold, cyanosis	1- 6-32	Ligation of subclavian artery third portion; elective ligation of vein	Negative	At first ischæmia with gangrene of tips of fingers; swelling; pain; ulceration; patient still in hospital at time of writing; circulation improving gradually	Vascular lesion was associated with injury to brachial plexus; at time of writing seemed that probably he would require amputation because of total loss of function
		Embolism and thrombosis of left femoral and popliteal arteries	Inadequate	11-24-27	Embolectomy and partial removal of thrombus; ligation of left femoral artery; elective ligation of left popliteal vein	Negative	Died 11-28-27; at necropsy myocardial degeneration with infarction, hypertension, and gangrene of left leg and foot	Cases of embolus should not be compared with the other vascular lesions in this table because of unknown extent of thrombotic occlusion

our cases in which the Henle-Coenen sign was recorded. We are fully in agreement with Matas on the necessity of determining the efficiency of the collateral circulation before operation, and we believe that the circulation should be tested by the several methods which have gained acceptance by those experienced in surgery of the vascular system. Nevertheless, it is our conviction that the Henle-Coenen sign affords a valuable and practical index to the need for ligation of the concomitant vein, and we believe that this point may be adequately determined by noting at operation the condition of that segment of the artery immediately distal to the site of the lesion. In other words, if any pulsation is perceptible, or if there is arterial backflow when the vessel has been opened surgically, even though slight, one is safe in assuming that collateral circulation is probably sufficiently well developed to render simultaneous ligation of the accompanying vein unnecessary. It is obvious, as we have pointed out before, that the evil effects of chronic venous stasis are avoided as long as no great imbalance exists between the amount of venous blood and the amount of arterial blood. On the other hand, in cases in which there is no pulsation in the distal segment of the artery, or if there is no backward flow of blood in the event the vessel has been surgically opened, we believe that the satellite vein should be ligated, in order that more nearly equal distribution of the available blood may be induced. (Fig. 1.) Before drawing final conclusions, the blood-pressure in the brachial artery should be known, for obviously lowered systemic blood-pressure would affect local conditions materially. It is readily conceivable that in cases in which the systemic blood-pressure has been greatly depressed, as by hæmorrhage, shock, prolonged anæsthesia, or operation, there may not be sufficient flow of blood through an otherwise adequate collateral arterial tree to produce retrograde flow from the opening of the distal artery. Under these circumstances a negative Henle-Coenen sign would not necessarily indicate that collateral circulation would be subsequently deficient and in absence of preliminary tests of the efficiency of the collateral circulation, it would be impossible to determine the need of occlusion of the vein. In such instances, partial occlusion of the vein should be considered as a substitute for complete, permanent occlusion. This could be effected by narrowing the lumen of the vessels with a strip of fascia obtained from some nearby muscle sheath. We have not, so far, had an opportunity of trying this modification of partial occlusion, but we see no reason why, in border-line cases, it should not prove of value.

We consider a positive Henle-Coenen sign, therefore, as an absolute indication that collateral circulation is efficient. On the other hand, a doubtful positive, or even a negative Henle-Coenen sign, may not be an absolute indication of collateral circulatory inefficiency. There are several factors which may produce a border-line state with regard to the Henle-Coenen sign, and the decision to ligate the accompanying vein must take into consideration such influences as depression of systemic blood-pressure, peripheral vasomotor disturbances such as temporary vasospasm, and possible coëxistence of

chronic obliterative arterial disease. Even in instances in which a negative sign, or a very weak positive sign is obtained, it is conceivable that adequate collateral circulation may yet develop within the so-called critical time, and thus the onset of gangrene will be prevented. In this connection, the experimental work of Mulvihill and Harvey on peripheral thermic changes after arterial ligation and ganglionectomy, and also after section of the spinal cord or posterior roots and ganglionectomy, is of special interest. These investigators noted a fall in temperature of the foot after ligation of the corresponding iliac artery, and that the temperature returned gradually to its previous level after lapse of about thirteen hours. When the tributary sympathetic ganglia were removed simultaneously this fall in temperature did not occur, and when performance of sympathetic ganglionectomy was delayed until the temperature of the foot had dropped to that of the room, its return to normal was greatly accelerated. Transection of the spinal cord, or of the posterior roots below the level of the first lumbar vertebra, was without appreciable effect. In the opinion of Mulvihill and Harvey, their data suggest that reestablishment of former conditions by collateral circulation is a vasomotor phenomenon. It is possible, however, that the sudden anæmia incident to acute arterial occlusion may set up widespread peripheral vasoconstriction affecting the capillary bed extensively, and causing the temporary drop in temperature. Sympathetic ganglionectomy prevents or ameliorates this condition by removing vasopressor influences.

In contemplated operations for ligation of the artery, efficiency of the collateral circulation should be accurately determined by Matas' test, provided the proposed site of obstruction is situated in a part of the body where the artery is accessible to methods of intermittent compression. In instances in which the tests indicate collateral circulation to be deficient, great improvement may be obtained in almost all cases after a period of systematic intermittent compression of the artery according to the method of Matas. When such preliminary tests give evidence of efficient collateral circulation, we have never seen serious ischæmia ensue after occlusion of the artery. In operations for recent traumatism of the artery, or for aneurisms inaccessible to compression, it is highly desirable that the efficiency of the collateral circulation be determined at the time of the operation by elicitation of the Henle-Coenen sign, before deciding on the method of surgical treatment.

The records of The Mayo Clinic, from 1915 to 1931, show that there were sixty-five cases in which ligation or other obliterating type of operation was performed on large arteries and veins for relief of aneurisms, arterio-venous varices, and vascular tumors of various sorts. In this group there were twenty-nine cases in which the lesion was situated in the head or neck, or in which ligation of the large arteries of the head and neck was required. In the remaining thirty-six cases, there were lesions of the arterial trunks in or leading to the extremities. Of this group of thirty-six patients, the youngest was eight years of age and the oldest sixty-three years of age. The

average age of the patients was 35.5 years. Thirty-one of them were males and five females.

There were thirty-eight lesions in these thirty-six cases, as follows: traumatic aneurisms, nine; spontaneous aneurisms, ten (in association with only one of which was syphilis evident); arteriovenous aneurisms, twelve; and accidental wounding of large arteries, five. Furthermore, ligation because of hæmorrhage after embolectomy was performed in one case, and ligation to facilitate excision of neoplasm in one case. The sites of the lesions were as follows (two lesions in the same vessel in two cases); external iliac arteries, four cases; common iliac artery, one case; popliteal artery, five cases; axillary artery, one case; internal iliac artery, three cases; subclavian artery, three cases; brachial artery, four cases; common femoral artery, three cases; superficial femoral artery, nine cases, and deep femoral artery, three cases.

Both artery and vein were involved as follows: popliteal vessels, four cases; axillary vessels, two cases; common femoral vessels, one case; radial vessels, one case; peroneal vessels, one case, and superficial femoral vessels, two cases. Both right and left sides were involved in one case. The right side, therefore, was involved in eighteen cases and the left in nineteen cases (thirty-six patients in all). The artery alone was ligated in eighteen cases, whereas in twelve cases it was deemed necessary, for various reasons, to ligate the accompanying vein. In the other six cases the fistula of an arteriovenous varix was occluded.

In the group of eighteen cases in which a large artery alone required ligation there was complete recovery of function in ten cases, and considerable improvement in three cases. In one case there was associated bilateral thrombo-angiitis obliterans which was unrelieved, and in one an amputation through the upper part of the forearm was required because of a painful arteriovenous varix in the palm. In two cases there was persistent swelling and ulceration of the extremity. In one case there was secondary hæmorrhage and shock with beginning gangrene and the patient died. In the group of twelve cases in which both artery and vein were ligated, there were four in which ligation of the concomitant vein was performed as an elective procedure in an attempt to improve an already inadequate circulation, and in this group there was complete improvement in one and marked improvement in another. One of these patients died from auricular thrombosis and gangrene of the foot, and in one case painful, swollen extremities with ulcerations developed. In the remaining eight cases of this group of twelve in which ligation of both artery and vein was performed, the results were as follows: complete recovery in five cases and marked improvement in one case. Two patients died in hospital of bronchopneumonia, one had gangrene of the extremity, and the other, marked œdema of the limb on the side on which both vessels had been ligated.

In the group of eleven cases in which arteriovenous aneurisms were found (in six of which the fistula was obliterated, and in five, other operations

were performed) the results were good in eight cases. One patient required amputation because of a painful arteriovenous varix of the hand, and one had persistent swelling, pain and ulceration in the extremity. There was one death in this group from infection and gangrene.

In the entire group of thirty-six cases there were five deaths in hospital, two from bronchopneumonia and gangrene, one from gangrene and infection in an amputation stump, one from auricular thrombosis and gangrene of the foot, and one from hæmorrhage and shock with gangrene. In three of these cases, both main vessels were occluded by ligature at operation, and in one case secondary hæmorrhage, infection and gangrene followed ligation for a popliteal arteriovenous communication. In the remaining case, the right subclavian artery was ligated because of hæmorrhage eight days after an operation for bilateral cervical rib. The patient died the same day, and at necropsy thrombosis of the right brachial artery and gangrene of the fingers were noted.

The following case record is reported in detail because it demonstrates the value of ligation of the vein in the presence of existing ischæmia with threatening gangrene.

A man, aged sixty-three years, was admitted to The Mayo Clinic February 6, 1931, complaining of infection in the right foot, of six weeks' duration, and "rheumatism" of the thigh, and of the muscles of the right calf, intermittently for the last ten years. Disability included aching and tenderness in the right inguinal region, induced by walking and relieved by application of dry heat. Five years before, he had noticed a swelling in the right popliteal region, which gradually had increased. One week before he came to the clinic the pain became much worse, and at the same time the third and fifth toes of the right foot became discolored. There was no increased swelling in the extremity.

Physical examination gave essentially negative results except that a firm, irregular mass was found occupying the right femoral triangle. The mass apparently was fixed to the deeper structures. There was no fluctuation and no pulsation, and the overlying skin was not involved. Pulsation of the external iliac artery could be felt above the mass, but there was no pulsation of the femoral artery immediately below it. A similar mass about five centimetres in diameter occupied the popliteal region. The right foot exhibited marked cyanosis on dependency, and a considerable degree of blanching on elevation, and was perceptibly cooler than the left. Palpation of the peripheral vessels on the two sides of the body disclosed normal pulsations in all vessels on the left side, but pulsations in the femoral, popliteal, dorsalis pedis, and posterior tibial arteries of the right side were totally absent. There were trophic changes in several of the toes of the right foot, but in the small toe, there was definite gangrene of the first stage. The urine was normal; the value for hæmoglobin, and the erythrocyte count were normal, but leucocytes numbered 15,200 in each cubic millimetre of blood. Röntgenological examination of the pelvis gave evidence of a foreign body, possibly a shot just over the right acetabulum; no lesions of the vessels of the extremities could be demonstrated. The Wassermann reaction of the blood was negative. A diagnosis of occlusion of the arteries of the right leg, with gangrene of the first stage of the right fifth toe, was made. The nature of the masses in the groin and in the popliteal space could not be determined, but the diagnosis seemed to lie between a malignant neoplasm on the one hand, and an aneurism on the other. February 2, 1931, the femoral triangle was explored. An aneurism of the right femoral artery, beginning just below Poupart's ligament, and

producing a mass about nine by six by six centimetres, was found. The sac was fusiform, and was entirely filled with old clotted blood; there were no pulsations, either expansile or transmitted. In attempting to define the limits of the sac, the femoral vein was accidentally perforated to such extent that ligature seemed indicated. The aneurism



FIG. 2.—Appearance of leg at time of dismissal of patient (Case XI) whose right femoral artery was the site of aneurism with occlusion by a clot, and whose right femoral vein was ligated.

was then opened and the clot evacuated. There was no fresh bleeding until forceps were introduced into the proximal opening, and then a free flow of arterial blood occurred. The distal part of the artery could not be found, and there was no bleeding from the opened end of the distal portion of the aneurism. The aneurism, therefore, was obliterated by endo-aneurismorrhaphy. The most interesting feature of the case was that on the second day after operation there was noticeable improvement in circulation. One week after operation, the foot was warm and presented a normal, pink color. The regions of beginning gangrene seemed to be clearing up. There was no obvious œdema from ligation of the vein. Two weeks later, the condition of the foot was remarkably improved and although there was still much scaling over the area of the chemical burn, the crusting lesions of the first toe were rapidly disappearing. Fig. 2 shows the appearance of the limb at the time of the patient's dismissal from the clinic March 10, 1931, after an uneventful convalescence; the area of gangrene was entirely healed.

We heard from this patient July 20, 1931; he reported that he was in good general health, and that his foot was doing well. (Fig. 2.)

CONCLUSIONS.—Ligation of the main venous channel at the time of ligation of its companion artery in cases of inadequate collateral circulation is a valuable procedure. It is definitely contra-indicated in cases in which collateral circulation is adequate, because of the prolonged circulatory imbalance likely to be induced. In cases in which collateral circulation is inefficient, ligation of the concomitant vein provides more homogeneous distribution of the available blood and increases the chances of survival of the limb beyond the so-called critical time. Efficiency of the collateral circulation should be determined as accurately as possible

before operation, and confirmed at operation by employment of methods such as we have described (Henle-Coenen sign). When the Henle-Coenen sign is positive, ligation of the accompanying vein is contra-indi-

cated, and when this sign is negative, ligation of the main venous channel is advocated.

BIBLIOGRAPHY

- ¹ Bernheim, B. M., and Worth, Peregrine, Jr.: Arteriovenous Aneurism of the External Iliac Vessels with Wound of the External Iliac Vein. *ANNALS OF SURGERY*, vol. lix, pp. 558-562, April, 1914.
- ² Boeckel, J.: Quoted by Mulvihill, Harvey and Doroszka.
- ³ Brooks, B.: Surgical Applications of Therapeutic Venous Obstruction. *Arch. Surg.*, vol. xix, pp. 1-23, July, 1929.
- ⁴ Brooks, B., and Johnson, G. S.: An Experimental Study of the Distribution of the Peripheral Blood Flow. *Jour. Bone and Joint Surg.*, vol. xiv, pp. 102-108, January, 1932.
- ⁵ Brooks, Barney, and Martin, K. A.: Simultaneous Ligation of Vein and Artery. *Jour. Am. Med. Assn.*, vol. lxxx, pp. 1678-1681, June 9, 1923.
- ⁶ Coenen, H.: Zur Indikationsstellung bei der Operation der Aneurysmen und bei den Gefassverletzungen. *Zentralbl. f. Chir.*, vol. 40, pp. 1913-1916, December 13, 1913.
- ⁷ Ferris, H. W., and Harvey, S. C.: A Physiological Study of the Development of the Collateral Circulation in the Leg of the Dog. *Proc. Soc. Exper. Med. and Biol.*, vol. xxii, pp. 383-386, 1924-1925.
- ⁸ von Frisch, O.: Zur Indikationsstellung bei der Operation der Aneurysmen und bei den Gefassverletzungen. *Zentralbl. f. Chir.*, vol. 41, pp. 89-90, January 17, 1914.
- ⁹ Griebel, Ernst: Über traumatische Bauchgefassaneurysmen im Anschluss an einen Fall von falschen Aneurysma: nach Abschuss der Milzgefasse und einen Fall von traumatischem intrahepatischem Aneurysma. *Ztschr. f. Chir.*, vols. cliv-clv, pp. 338-409, 1920.
- ¹⁰ Halsted, W. S.: Ligation of the Left Subclavian Artery in Its First Portion. *Johns Hopkins Hosp. Rept.*, vol. xxi, pp. 1-96, 1921.
- ¹¹ Heitz, Jean: Ligatures et sutures arterielles. *Arch. d. mal. du coeur.*, vol. xvi, pp. 216-236, 1923.
- ¹² Henle, A.: Zur Indikationsstellung bei der Operation der Aneurysmen und bei den Gefassverletzungen. *Zentralbl. f. Chir.*, vol. 41, p. 91, January 7, 1914.
- ¹³ Holman, Emile: Observation on the Surgery of the Large Arteries. *ANNALS OF SURGERY*, vol. lxxxv, pp. 173-184, February, 1927.
- ¹⁴ Holman, Emile, and Edwards, Muriel: A New Principle in the Surgery of the Large Vessels. *Jour. Am. Med. Assn.*, vol. lxxxviii, pp. 909-911, March 19, 1927.
- ¹⁵ LaRoque, G. P.: Ligation of the External Iliac Artery and Vein Above and Below a Communicating Bullet Wound of These Two Vessels. *ANNALS OF SURGERY*, vol. lxxiii, pp. 265-284, March, 1921.
- ¹⁶ Makins, G. H.: The Bradshaw Lecture on Gunshot Injuries of the Arteries. *Brit. Med. Jour.*, vol. ii, pp. 1569-1576, December 20, 1913; *Lancet*, vol. ii, pp. 1743-1752, December 20, 1913.
- ¹⁷ Makins, G. H.: The Hunterian Oration on the Influence Exerted by the Military Experience of John Hunter on Himself and the Military Surgeon of Today. *Lancet*, vol. i, pp. 249-254, February 17, 1917.
- ¹⁸ Makins, G. H.: On Gunshot Injuries to the Blood-vessels. Bristol, J. Wright and Sons, 1919, 251 pp.
- ¹⁹ Matas, R.: Testing the Efficiency of the Collateral Circulation as a Preliminary to the Occlusion of the Great Surgical Arteries. *Jour. Am. Med. Assn.*, vol. lxiii, pp. 1441-1447, 1914.
- ²⁰ McNealy, R. W.: The Place of Elective Vein Ligation on Blood-vessel Surgery. *Surg., Gynec., and Obst.*, vol. xl, pp. 45-48, January, 1925.

- ²¹ Montgomery, M. L.: Therapeutic Venous Occlusion. *Arch. Surg.*, vol. xxiv, pp. 1016-1027, June, 1932.
- ²² Mulvihill, D. A., and Harvey, S. C.: Studies on Collateral Circulation. I. Thermic Changes After Arterial Ligation and Ganglionectomy. *Jour. Clin. Investigation*, vol. x, pp. 423-429, August, 1931.
- ²³ Mulvihill, D. A., Harvey, S. C., and Doroszka, Vincent: Simultaneous Ligation of Vein in Ligation of Large Arteries. *Am. Jour. Surg.*, vol. xiii, pp. 431-452, September, 1931.
- ²⁴ Oppel, W. A.: Wieting's Operation und der reduzierte Blutkreislauf. *Zentralbl. f. Chir.*, vol. ii, pp. 1241-1242, August 2, 1913.
- ²⁵ Pearce, H. E., Jr.: The Use of Vein Ligation in the Treatment of Arteriosclerotic and Diabetic Gangrene. *Jour. Am. Med. Assn.*, vol. xcvi, pp. 866-870, March 12, 1932.
- ²⁶ Propping, Karl: Ueber die Ursache der Gangrän nach Unterbindung grosser Arterien. *München. med. Wchnschr.*, vol. i, pp. 598-599, May, 1917.
- ²⁷ Quénu and Muret: Sur le traitement moderne des aneurismes poplités. *Rev. de chir.*, vol. xli, pp. 282-294, January, 1910.
- ²⁸ Sehrt, E.: Über die künstliche Blutleerne von Gliedmassen und unterer Körperhälfte, sowie über die Ursache der Gangrän des Gliedes nach Unterbindung der Arterie allein. *Med. Klin.*, vol. xii, pp. 1338-1341, December, 1916.
- ²⁹ Stoltz, Carl: Eine Indikation zur Wahl der Operationsmethode bei Aneurysmen, erläutert an zwei Fällen von Aneurysma der Arteria femoralis. *Beitr. z. klin. Chir.*, vol. lxxxviii, pp. 452-465, January, 1914.
- ³⁰ Theis, F. V.: Ligation of Artery and Concomitant Vein in Operations on the Large Blood-vessels. *Arch. Surg.*, vol. xvii, pp. 244-258, August, 1928.
- ³¹ Tuffier, M.: A propos des plaies des arteres. *Bull. et mém. Soc. de chir. de Par.*, vol. xliii, pp. 1469-1471, 1917.
- ³² Van Kend: Quoted by Mulvihill, Harvey, and Doroszka.
- ³³ Zondek: Hohe Unterbindung der Arteria und Vena femoralis. *Berl. klin. Wchnschr.*, vol. xlix, pp. 559-560, March, 1912.

MEMOIRS
FRANK L. HUPP, M.D.
1929



FRANK L. HUPP, M.D.

DR. FRANK LEMOYNE HUPP was elected a member of the American Surgical Association in 1919. He received the degree of M.D. in 1889 from

the College of Physicians and Surgeons of New York, and for two years thereafter was a member of the house staff of the Presbyterian Hospital in the same city.

Frank LeMoynes Hupp was born at Wheeling, West Virginia, July 8, 1865. For years he had looked forward to practising surgery in Wheeling, W. Va., and his entire professional career was pursued in that city. He quickly became attached to the staffs of several hospitals and was soon recognized as a leading surgeon, not only in Wheeling, but in the adjacent Ohio Valley as well. Although never a prolific writer, his contributions to surgical literature, including papers read by him before this Association, were of a clinical character, sound, carefully prepared and invariably of a high order of merit.

On December 26, 1929, while engaged in the daily routine of surgical work, and without previous warning, he sustained an apoplectic seizure from which he died without regaining consciousness.

Doctor Hupp possessed many unusual attributes. Ambitious, energetic, and endowed with a strong constitution, he devoted himself to the practise of his profession with the greatest enthusiasm; and yet he never neglected the duties of a citizen and spared no effort to develop and improve the welfare of the community in which he lived. Generally respected and admired, his sterling character and his attractive personality endeared him to many friends and commanded the confidence of all who knew him.

ELLSWORTH ELLIOTT.

WALTER AIKMAN SHERWOOD, M.D.

1875-1931

DR. WALTER A. SHERWOOD, of Brooklyn, N. Y., died November 21, 1931, in the fifty-sixth year of his age. He was born in Jersey City, New Jersey, December 25, 1875. His primary education was at the Hasbrouck Institute of that City and at Rutgers College, New Brunswick, which institution in later years conferred upon him the honorary degree of Doctor of Science. After a course of two years at Rutgers, during which he specialized in the classics and in biology, he matriculated at the College of Physicians and Surgeons of Columbia University from which school he received his degree of M.D. in June, 1896.



WALTER A. SHERWOOD, M.D.

The course of his education was well planned to prepare for the practice of medicine. While an undergraduate he served in surgical positions for brief periods at the Roosevelt Hospital, Bellevue Hospital and the Vanderbilt Clinic of New York and finally after graduation had a service of two years as an interne in the Methodist Episcopal Hospital of Brooklyn. At the close of this internship he was appointed the Assistant to the First Surgical Service (Dr. Lewis S. Pilcher) of the hospital. In November, 1899, he entered upon his work as a general practitioner in the city of Brooklyn. In the course of the years he was a member of the Kings County Medical Society, Brooklyn Surgical Society, Brooklyn Pathological Society, The Society of Associated Physicians of Long Island, The New York Surgical Society and the American Surgical Association. He was elected a Fellow of the last Association in 1927. With this foundation and these associations, added to his native qualities, he developed a professional career of marked success characterized by broad accomplishments, unusual sagacity, thorough devotion to the highest principles of his profession and admirable citizenship. Repeated visits to the clinics of Europe added to his information and skill. After a period of six years as an assistant surgeon in the Methodist Episcopal Hospital he was made an attending surgeon and served that institution as such from 1908 to 1916. In 1914 he was made also an associate surgeon in the Brooklyn Hospital in which institution his main work was done during the latter years of his life, having been made a full attending surgeon

in 1916, with advancement to the Directorship of Surgery in 1925, a position which he held to the time of his death.

In his entire career he exemplified a deliberate purpose to secure the highest attainment in the profession which he had chosen. In addition to the head of the department of surgery in a great hospital in the city of his residence, he held such honorary positions as Consulting Surgeon to the Methodist Episcopal Hospital and the Eastern Long Island Hospital. He presented many papers before surgical societies. He made frequent journeys to foreign lands for study and recreation.

He entered the service of the U. S. Army in 1918 and the following year he received the rank of Lieutenant-Colonel and was made the Chief Surgeon of the U. S. A. General Hospital No. 1, at Williamsbridge, in the vicinity of New York City, which position he held to the close of the war.

As a surgeon he was fully founded in all the requirements of its science and art. More than this to his scientific acquirements he brought a quality of kindness and courtesy which gave him a most attractive character. To his fine professional abilities he added high standards of ethical conduct so that his career was an inspiration to those that had the privilege of his acquaintance, and the memories of his life remain as a highly cherished treasure to his colleagues and friends.

LEWIS S. PILCHER.

EDITORIAL ADDRESS

The office of the Editor of the Annals of Surgery is located at 386 Park Street, Upper Montclair, New Jersey. All contributions for publication, Books for Review, and Exchanges should be sent to this address.

Remittances for Subscriptions and Advertising and all business communications should be addressed to the

ANNALS OF SURGERY
227-231 South Sixth Street
Philadelphia, Penna.

INDEX FOR VOLUME XCVI

A

- Abdomen, Penetrating Wounds of the, 161.
 Abdominal Gunshot Injuries, the Influence of Hæmorrhage in, 169.
 Abdominal Incisions and Their Closure, 555.
 ABRAMSON, PAUL D.: Insulin and Surgery, 49.
 Abscess, Perinephritic, 998.
 ADAIR, FRANK E.: Extensive Squamous Carcinoma Treated by Interscapulothoracic Amputation, 303; Intrapelvic Neurogenical Sarcoma, Treated by Irradiation, 305; Unusual Complications in a Case of Mammary Cancer, 302.
 ADSON, ALFRED W.: Sympathetic Ganglionectomy, 771, 786.
 Aërophagia, 113.
 Agranulocytosis and Peri-anal Phlegmon, 108.
 ALLEN, ARTHUR W.: Peripheral Vascular Lesions, 783; Raynaud's Disease, Results Obtained by Sympathetic Neurectomy, 867.
 American Surgical Association, Transactions of, Meeting of 1932, 481, 801, 1903.
 Anæsthesia, Spinal, 85.
 ANDREWS, EDMUND: Cholesterol Gallstone Formation, 616; Embolectomy, 40.
 Aneurism of Innominate Artery, 666; Subclavian, 670.
 Ankle, Pott's Fracture of, 1078.
 Appendectomy, Fecal Fistula after, 158.
 Appendicitis, Acute, 530; Diffuse Suppurative, 543, 549; Chronic Obliterative, 515; Peritonitis, 537.
 Appendix, Etiology of Inflammatory and Degenerative Diseases of the, 451; Myxoglobulosis (von Hanseman) of the, 456; Vermiformis, Length and Position of, 1044.
 Arterial Diseases, Vasoconstrictor Spasm in, 754.
 Arteries, Traumatic Lesions of, Indications for Ligation of Veins, 1098.
 Arteries of Extremities, Embolectomy in, 44.

- Artery Innominate, Aneurism of, 666.
 Arthrotomy, Knee-joint, 17.
 Axilla, Carcinoma of, Interscapulothorax Amputation for, 303.
 Azygos Vein, Ligation of, 716.
 Azygos Venous System and Sepsis, 686.

B

- BACHE, WILLIAM: Infrequency of Carcinoma of Cervix with Complete Procidencia, 796.
 BAILEY, FRED WARREN: Acute Appendicitis, 530.
 BAILEY, HUGH A.: Appendicitis with Peritonitis, 537.
 BALFOUR, DONALD C.: Hæmorrhagic Duodenal Ulcer, 581, 587.
 BALLIN, MAX: Parathyroidism, 649.
 BANCROFT, FREDERIC W.: Therapeutic Management of Postpyloric Ulcer, 1036.
 BEEKMAN, FENWICK: Skin Grafting in Cases of Severe Burns, 305.
 BEER, EDWIN: Azygos Venous System and Sepsis, 686; Gall-stones, Causes of, 615; Sympathetic Ganglionectomy, 786.
 BEHREND, MOSES: Fecal Fistula after Appendectomy, 158.
 Benign Tumors of the Stomach, 240.
 BERNHEIM, BERTRAM M.: Partial and Total Devascularization of the Stomach, 179.
 BERRY, MARK B.: The Fissures of the Lungs, 961.
 BEST, R. RUSSELL: The Vagus Nerve and Its Relation to Peptic Ulcer, 184.
 BEVAN, ARTHUR DEAN: Abdominal Incisions and Their Closure, 555, 573.
 Biceps Tendon, Avulsion of, 114.
 Bile-duct Stone, Lipiodol in Diagnosis of Retained Common, 474.
 BIRNBAUM, I. R.: Thiocresol in Wound Healing and in Skin Grafting, 467.
 BLALOCK, ALFRED: Fatal Burns, Cause of Death, 36.
 BLOODGOOD, JOSEPH COLT: Radium, X-ray, When Should Irradiation with, Precede Operation, or Be Employed without Operation, 882.

- Bobbin Attachment to Scissors or Needleholder for Ligating and Sewing, 472.
- BOOKMAYER, R. H., AND JAMES E. DAVID: Intramural Calcification of the Gall-bladder, 413.
- Breast Cancer, Inflammatory Cyst of the, 460; Late Results in the Operative Treatment of Carcinoma of the, 286, 318; Radical Operations for Carcinoma of the, 1098; Results of Operative Treatment, 871; Unusual Complications of Cancer of, 302.
- BRUCE, HERBERT A.: Thyroidectomy, Paralysis Abductor Temporal Bilateral with Tetany Following, 864.
- BUCHANAN, EDWIN PORTER: Internal Hernia Following Posterior Gastroenterostomy, 359.
- Burns, Fatal, Cause of Death, 36; Severe, Skin Grafting in Cases of, 305.

C

- Calcium Carbonate Gall-stones, 595.
- Calculi, Salivary, 979.
- CAMPBELL, WILLIS C.: Operative Treatment of Paralytic Genu Recurvatum, 1055.
- Cancer Problem in the General Hospital, 857.
- Carcinoma, of Axilla, Interscapulo-amputation for, 303; of Cervix Uteri with Procidencia, 796; of the Hepatic Duct, 381; of the Mouth and Tongue, 488; of the Sigmoid, 315; of the Stomach, 111, 588.
- Carcinoma of the Breast, Late Results in the Operative Treatment of, 286, 318; Radical Operations for, 1093; Results of Operative Treatment, 871; Unusual Complications, 302.
- CARSON, WILLIAM J.: Ureteral Obstruction, 156.
- CARTER, RUPERT FRANKLIN: Intussusception in Infancy, 94.
- Cartilage, Semilunar, Excision of Internal, 115.
- CAVE, HENRY W.: Tumors of the Small Intestine, 269.
- Cerebellar Route, in operating for Trigeminal Neuralgia, 787.
- Cervix Uteri, Carcinoma of, with Procidencia, 796.
- CHEEVER, DAVID: Stomach and Intestines, Treatment of Primary Lymphosarcoma of, 911.
- CHILDS, EDWARD P.: The Fissures of the Lungs, 961.
- Cholecystitis, Active, the Surgical Treatment of, 406.
- Cholesterol Gall-stone Formation, 616.
- CLURMAN, MORRIS J., AND WILLIAM L. WOLFSON: A Cork Adjuvant to the Murphy Button, 478.
- COLEY, WILLIAM B.: Closure of Large Ventral Incisions, 572.
- COLLER, FREDERICK A.: Skin Temperature Indications, 719.
- Colon, Resections of, 102.
- Compound Fractures, Treatment of, 128.
- CONNELL, F. GREGORY: Resection of the Fundus of the Stomach for Peptic Ulcer, 200.
- COOKE, H. HAMILTON: Traumatic Rupture of the Intestines Caused by Automobile Accidents, 321.
- COOPERMAN, MORRIS B.: Chronic Tuberculous Polyarthritides, 1065.
- Cork Adjuvant to the Murphy Button, 478.
- CRILE, GEORGE W.: Arresting Internal Hemorrhage, 588; Thyroidectomy in Tuberculosis, 647.
- CURTIS, LAWRENCE: Salivary Calculi, 979.
- Cutaneous Gangrene, Progressive, Post-operative, 1086.
- CUTLER, CONDUCT W., JR.: Agranulocytosis and Peri-anal Phlegmon, 108; Intestinal Obstruction from Gall-stones, 107; Plastic Repair of Injury to Thumb, 110.
- Cyst, Inflammatory, of the Breast, 460.
- Cystic Mastitis, Chronic, 149.
- Cysts, Mesenteric, 112; a study of, 329; and Omental, 340.

D

- DANDY, WALTER E.: Trigeminal Neuralgia, Cerebellar Route of Attack, 705, 787.
- DAVID, VERNON C.: Carcinoma of the Hepatic Duct, 381.
- DAVIS, JAMES E., AND R. H. BOOKMAYER: Intramural Calcification of the Gall-bladder, 413.
- DAVIS, LINCOLN: Bleeding Duodenal Ulcers, 586.
- DAY, LOIS: Calcium Carbonate Gall-stones, 595.

DE TAKATS, GEZA, AND WALLACE D. MACKENZIE: Acute Pancreatic Necrosis and Its Sequelæ, 418.
 Diabetes and Chronic Gall-bladder Disease, 70.
 Disc-choked, in Exophthalmic Goitre, 995.
 Dislocation, Radio-ulnar, Recurrent Inferior, 27.
 DONALD, JOSEPH M.: Sarcoma of the Kidney of the Adult, 1017.
 DOSTAL, L. E.: Cholesterol Gall-stone Formation, 616.
 DOUGLAS, JOHN: Tuberculosis of the Thyroid Gland, 647.
 DUFFIELD, WARREN L.: Pericolic Membranes, 98.
 Duodenal Ulcer, Hæmorrhagic, 581; the Choice of Surgical Procedures for, 258.
 Duodenum, Obstruction of the, Caused by Enlarged Retroperitoneal Glands, 219.

E

EGGERS, CARL: Radical Operations for Carcinoma of the Breast, 1098.
 ELIASON, ELDRIDGE L.: Recurrent Inferior Radio-ulnar Dislocation, 27; and L. K. FERGUSON: Splenectomy in Purpura Hæmorrhagica, 801.
 ELIOTT, ELLSWORTH, JR.: Closing Large Ventral Openings, 571; Memoir of Frank L. Hupp, 1118; Subclavian Aneurism, 670.
 Embolectomy, 40; in Arteries of Extremities, 44.
 Embolism, Fat, 75.
 Empyæma of Thorax, Acute, 987.
 ESTES, WILLIAM L.: Advanced Gastrojejunal Ulcer, 250.
 ESTES, WILLIAM L., JR.: Intestinal Obstruction, Fate of the Obstructed Loop in, 924.
 Exophthalmic Goitre, Orbital Myositis and Choked Disc in, 995.
 Extremities, Embolectomy in Arteries of, 44.

F

Fascial Sutures, Obtaining Living, 159.
 Fat Embolism, 75.
 Fecal Fistula after Appendectomy, 158.
 Feeding, Gravity, in Jejunostomy, 225.

Femur, Fracture of Epiphysis of the Head of the, 313; Fractures of Neck of, 1, 951.
 FERGUSON, L. K.: Splenectomy in Purpura Hæmorrhagica, 801.
 FISCHER, HERMANN: Diverticulitis of Sigmoid, Carcinoma of, 315; Splenectomy for Movable Spleen, Torsion of Pedicle, 317.
 Fissures of the Lungs, 691.
 Fistula, Fecal, after Appendectomy, 158.
 FLICK, JOHN B.: Spirochætal Infections of Hand, 118.
 FOSS, HAROLD L.: Cancer Problem, in the General Hospital, 857.
 Fracture, Pott's, Treatment of, 1078.
 Fractures, Compound, Treatment of, 128; of Neck of Femur, 1, 951.
 FRASER, JOHN: Carcinoma of Mouth and Tongue, 488.
 FRAZIER, CHARLES H.: Cerebellar Route in Operations for Trigeminal Neuralgia, 793.
 FREEMAN, LEONARD: Obliterating Appendicitis, 546.
 FRIEDENWALD, JONAS S.: Orbital Myositis and Choked Disc in Exophthalmic Goitre, 995.
 FULD, JOSEPH E.: Obtaining Living Fascial Sutures, 159.

G

Gall-bladder, Intramural Calcification of the, 413.
 Gall-bladder Disease, Chronic, and Diabetes, 70.
 GALLIE, WILLIAM EDWARD: Closing Large Hernial Openings, 551, 573.
 Gall-stone Formation, Cholesterol, 616.
 Gall-stones, Calcium Carbonate, 595; Intestinal Obstruction from, 107.
 Gangrene, Progressive Post-operative Cutaneous, 1091.
 GARLOCK, JOHN H. A.: Excision of Internal Semilunar Cartilage, 115.
 GARSIDE, EARL: Intravenous Sclerosing Injections, 691.
 Gastrectomy for Lymphosarcoma in Childhood, Partial, 210.
 Gastric Aberrant Mucosa, Ulceration of, in Meckel's Diverticulum, 893.
 Gastric Mucosa Prolapse, 140.
 Gastric Polyp, Redundant, 140.
 Gastroenterostomy, Internal Hernia Following Posterior, 359.

- Gastrojejunal Ulcer, Advanced, 250.
 GATEWOOD, GATEWOOD: Carcinoma of the Stomach, 588.
 Genu Recurvatum, Paralytic, Operative Treatment of, 1055.
 GIBBON, JOHN H.: Resections of Colon, 102; Transfusions in Gastric Hæmorrhage, 587.
 GIBSON, CHARLES I.: Closure of Large Ventral Hernias, 571.
 GILL, A. BRUCE: Fractures of Neck of Femur, 1.
 GINZBURG, LEON: Lipiodol in Diagnosis of Retained Common Bile-duct Stone, 474; X-ray Diagnosis of Acute Intestinal Obstruction without the Use of Contrast Media, 368.
 GOFF, M.: Cholesterol Gall-stone Formation, 616.
 GOITRE, Exophthalmic, Orbital Myositis and Choked Disc in, 995.
 GOLDBERG, SAMUEL L.: Experimental Peptic Ulcer, 155.
 GOLDBLATT, DAVID: Treatment of Pott's Fracture, 1083.
 GRACE, RODERICK V.: Lingual Thyroid, 973.
 GRAHAM, A. STEPHENS: Tuberculosis of Thyroid Gland, 625.
 GRAHAM, HENRY F.: Removing Stones from Ducts within Liver, 154.
 Gravity Feeding in Jejunostomy, 225.
 GUERRY, LE GRAND: Appendicitis, 546.
 Gunshot Injuries of Abdomen, the Influence of Hæmorrhage in, 169.
 GUTHRIE, DONALD: Infrequency of Carcinoma of Cervix Uteri with Complete Procidentia, 796.

H

- Hæmorrhage, in Abdominal Gunshot Injuries, the Influence of, 169; Meningeal, without Intracranial Symptoms, 462; the Prediction of, in Obstructive Jaundice by the Sedimentation Rate, 385.
 Hæmorrhagic Duodenal Ulcer, 581.
 HALE, KELLEY: Bobbin Attachment to Scissors or Needle-Holder for Ligating and Sewing, 472.
 Hand, Spirochætal Infections of, 118.
 HARKINS, HENRY: Embolectomy, 40.
 HARRINGTON, STUART W.: Mediastinal Tumors, Surgical Treatment of, 843.

- HARRISON, JR., W. GEORGE: Fatal Burns, Cause of Death, 36.
 HARVEY, SAMUEL C.: Sympathetic Vasomotor Pathways, 744.
 HASTINGS, A. BAIRD: Calcium Carbonate Gall-stones, 595.
 HEEKS, WILLIAM G.: Maggots and Osteomyelitis, 930.
 HENTZ, VICTOR G.: Myxoglobulosis (von Hanseman) of the Appendix, 456.
 Hepatic Duct, Carcinoma of, 381.
 Hernia, Internal, Following Posterior Gastroenterostomy, 359; Perimesenteric Intra-abdominal, 292; of the Ureter, 575.
 Hernial Openings, 551.
 HEUER, GEORGE J.: Tumors of the Sternum, 830.
 HICKEN, N. F.: Perinephritic Abscess, 998.
 HIGGINS, CHARLES C.: Perinephritic Abscess, 998.
 HINTON, J. WILLIAM: Chronic Interlobular Pancreatitis, 441.
 HOMANS, JOHN: Thrombosis of Varicose Veins, 716.
 HORSLEY, J. SHELTON: Chronic Obliterative Appendicitis, 515, 550.
 HRDINA, L.: Cholesterol Gall-stone Formation, 616.
 HUNT, VERNE C.: Partial Gastrectomy for Lymphosarcoma in Childhood, 210.
 HUPP, FRANK L.: Memoir of, 1118.
 Hypospadias, 114.

I

- Incisions, Abdominal, and Their Closure, 555.
 Infancy and Childhood, Malignant Tumors of the Kidney in, 1017.
 Infants, under One Year of Age, Peptic Ulcer in, 204.
 Infections, Spirochætal, of Hand, 118.
 Injections, Intravenous Sclerosing, 691.
 Innominate Artery, Aneurism of, 666.
 Insulin and Surgery, 49.
 Internal Hernia Following Posterior Gastroenterostomy, 359.
 Intestinal Distention, Pituitary Extract in the Prevention of Post-operative, 364.
 Intestinal Obstruction, Fate of the Obstructed Loop in, 924; from Gall-stones, 107.

Intestine, Tumors of the Small, 269.
 Intestines, Rupture of the, Caused by Automobile Accidents, 321.
 Intra-abdominal Hernia, Perimesenteric, 292.
 Intravenous Sclerosing Injections, 691.
 Intussusception in Infancy, 94.
 IVY, ROBERT H.: Salivary Calculi, 979.

J

Jaundice, the Prediction of Hæmorrhage in Obstructive, by the Sedimentation Rate, 385; the Relation of the Blood Fibrin to the Hæmorrhagic Diathesis of Obstructive, 394.
 JEFFERIES, JOHN W.: Pseudomyxoma Peritonei, 215.
 Jejunostomy, Gravity Feeding in, 225.
 JONES, HAROLD WELLINGTON: Spinal Anæsthesia, 85.
 JUDD, E. STARR: Sarcoma of the Kidney of the Adult, 1028.

K

KERR, HARRY H.: Sympathetic Ganglionectomy, 785.
 Kidney, Duplicated, Tuberculosis of Segment of, 1014; Malignant Tumors of, in Infancy and Childhood, 1017; Sarcoma of the, of the Adult, 1028.
 KLINGENSTEIN, PERCY: Late Results of Operative Treatment of Carcinoma of Breast, 286, 318.
 Knee-joint Arthrotomy, 17.
 Krukenberg Tumor of the Ovary, 1078.

L

LA ROQUE, G. PAUL: Benign Tumors of the Stomach, 240.
 LESTER, CHARLES W.: Therapeutic Management of Postpyloric Ulcer, 1036.
 LEWISOHN, RICHARD: Post-operative Shock Following Splenectomy for Chronic Thrombocytopenic Purpura, 447.
 LILIENTHAL, HOWARD: Closure of Extensive Abdominal Incisions, 572.
 Lingual Thyroid, 973.
 LINTON, ROBERT R.: The Relation of the Blood Fibrin to the Hæmorrhagic Diathesis of Obstructive Jaundice, 394.

Lipiodol in Diagnosis of Retained Common Bile-duct Stone, 474.
 Liver, Removing Stones from Ducts Within, 154.
 LORIA, FRANK L.: The Influence of Hæmorrhage in Abdominal Gunshot Injuries, 169.
 LUND, FRED. B.: Ligation of Thrombosed Veins, 717.
 Lungs, Fissures of the, 961.
 LYLE, HENRY H. M.: Avulsion of Biceps Tendon, 114; Hypospadias, 114.
 Lymphosarcoma in Childhood, Partial Gastrectomy for, 210.

M

MCCLAUGHAN, JOHN M.: Traumatic Lesions of Arteries. Therapeutic Ligation of Veins, 1103.
 MACKENZIE, WALLACE D., AND GEZA DE TAKATS: Acute Pancreatic Necrosis and Its Sequelæ, 418.
 MADDOCK, WALTER G.: Skin Temperature Indications, 719.
 Maggots and Osteomyelitis, 930.
 Malignant Tumors of the Kidney in Infancy and Childhood, 1017.
 MARTIN, JOHN D.: Inflammatory Cyst of the Breast, 460.
 MARTIN, WALTON: Maggots and Osteomyelitis, 930.
 MASON, JAMES M., AND GRAHAM, GEORGE S.: Gastric Aberrant Mucosa in Meckel's Diverticulum, Ulceration of, 893.
 MASON, J. TATE: Abdominal Incision, 573.
 Mastitis, Chronic Cystic, 149.
 MATAS, RUDOLPH: Ligating Inflamed Veins, 717; Oscillometry as a Circulatory Index, 785.
 MATHEWS, FRANK S.: Aërophagia, 113; Cancer of the Breast, Results of Operative Treatment, 871.
 MAYO, CHARLES H.: Surgery of the Sympathetic Nervous System, 481.
 MAYO, WILLIAM J.: Sympathetic Ganglionectomy, 771.
 Meckel's Diverticulum, Ulceration of Gastric Aberrant Mucosa, 893.
 Mediastinal Tumors, Surgical Treatment of, 843.
 Membranes, Pericolic, 98.

Meningeal Hæmorrhage without Intracranial Symptoms, 462.
 Mesenteric Cysts, 112.
 Mesenteric and Omental Cysts, 329, 348.
 MEYER, WILLY: Tumors, Inoperable and Malignant, 891.
 MITCHELL, JOSEPH I.: Operative Treatment of Paralytic Genu Recurvatum, 1055.
 MIXTER, CHARLES G.: Malignant Tumors of the Kidney in Infancy and Childhood, 1017.
 MIXTER, WILLIAM J.: Sympathetic Ganglionectomy, 785.
 MOORHEAD, JOHN J.: Knee-joint Arthrothomy, 17.
 MORTON, JOHN J.: Vasoconstrictor Spasm in Arterial Diseases, 754; Vasoconstrictive Effect of Tobacco, 786.
 MOSCHCOWITZ, ALEXIS V.: Hernia of the Ureter, 575; Tuberculosis of the Thyroid Gland, 646.
 Mouth and Tongue, Carcinoma of, 488.
 MUELLER, R. STERLING: Posterior Pituitary Extract in the Prevention of Post-operative Intestinal Distention, 364.
 Murphy Button, a Cork Adjuvant to the, 478.
 Myxoglobulosis (von Hanseman) of the Appendix, 456.

N

Nervous System, Sympathetic, Surgery of, 481.
 NEUHOF, HAROLD: Embolectomy in Arteries of Extremities, 44.
 Neuralgia, Trigeminal, Cerebellar Route, 787.
 Neurectomy, Sympathetic, in Raynaud's Disease, Results Obtained by, 867.
 NEW YORK SURGICAL SOCIETY, Transactions of, 102, 302.

O

Obstruction, Chronic Intestinal, Caused by Enlarged Retroperitoneal Glands, 219.
 Obstruction, Intestinal, from Gall-stones, 107; Ureteral, 156; X-ray Diagnosis of Acute—Without the Use of Contrast Media, 368.

OCHSNER, ALTON: Intravenous Sclerosing Injections, 691.
 Omental Cysts, 340.
 ORATOR, VICTOR: The Vagus Nerve and Its Relation to Peptic Ulcer, 184.
 Orbital Myositis in Exophthalmic Goitre, 995.
 Osteomyelitis, Chronic Recurring, Stannoxyl in the Treatment of, 1032.
 Osteomyelitis and Maggots, 930.
 OUGHTERSON, ASHLEY W.: Sympathetic Vasomotor Pathways, 744.
 OWEN, MAY, AND WHITE, RICHARD JOSEPH: Note on the Etiology of Acute Pancreatitis, 470.

P

Pancreatic Necrosis, Acute, and Its Sequelæ, 418.
 Pancreatitis, Acute, Note on the Etiology of, 470; Chronic Interlobular, 441.
 Parathyroidism, 649.
 PATTERSON, HOWARD ALEXANDER: Progressive Post-operative Cutaneous Gangrene, 1091.
 PEARSE, HERMAN E.: Recurrent Perforation of Peptic Ulcers, 192.
 PEMBERTON, JOHN DE J.: Traumatic Lesions of Arteries, Therapeutic Ligation of Veins, 1103.
 PENICK, RAWLEY M.: Chronic Obstruction of the Duodenum Caused by Enlarged Retroperitoneal Glands, 219.
 Peptic Ulcer, Experimental, 155; in Infants under One Year of Age, 204; of Meckel's Diverticulum, Perforated, 230; Resection of the Fundus of the Stomach for, 200; The Vagus Nerve and Its Relation to, 184.
 Peptic Ulcers, Recurrent, Perforation of, 192.
 Pericolic Membranes, 98.
 Perinephritic Abscess, 998.
 Peritoneum, Pseudomyxoma of, 215.
 Peritonitis, Appendicitis with, 537.
 PETERSON, EDWARD W.: Carcinoma of Stomach, 111; Intussusception in Infancy, 94; Mesenteric Cysts, 112; Mesenteric and Omental Cysts, 340.
 PFEIFFER, DAMON B.: Redundant Gastric Polyp, Gastric Mucosa Prolapse, 140.

PIEMISTER, DALLAS B.: Calcium Carbonate Gall-stones, 595, 615; Parathyroidism, 664.
 PHILADELPHIA ACADEMY OF SURGERY, Transactions of the, 118.
 Phlegmon, Peri-anal, and Agranulocytosis, 108.
 PILCHER, LEWIS S.: Memoir of Walter A. Sherwood, 1119.
 Pituitary Extract, Posterior, in the Prevention of Post-operative Intestinal Distention, 364.
 Plastic Repair of Injury to Thumb, 110.
 Poliomyelitis, Anterior, Surgical Possibilities in the Treatment of, 1049.
 Polyarthritis, Chronic Tuberculous, 1065.
 POOL, EUGENE H.: Drainage in Appendicitis, 545.
 Post-pyloric Ulcer, Therapeutic Management of, 1036.
 Pott's Fracture, Treatment of, 1083.
 PRIESTLY, JOSEPH B.: Tuberculosis of Segment of Duplicated Kidney, 1014.
 Purpura Hæmorrhagica, Splenectomy in, 80.

R

RABINOWITCH, ISRAEL M.: Chronic Gall-bladder Disease and Diabetes, 70.
 Radio-ulnar Dislocation, Recurrent Inferior, 27.
 Radium, When Should Irradiation Precede Operation or Be Employed without Operation?, 882.
 RANDALL, ALEXANDER: Recurrent Calculi in Urinary Tract, 133.
 RANKIN, FRED W.: Tuberculosis of Thyroid Gland, 625, 648.
 Raynaud's Disease, Results Obtained by Sympathetic Neurectomy, 867.
 REID, MONT R.: Peripheral Vascular Diseases, 733, 786.
 RENTSCHLER, CALVIN B.: Acute Empyæma of Thorax, 987.
 RICHTER, HELEN G.: Sympathetic Vasomotor Pathways, 744.
 RIENHOF, WILLIAM F.: Tuberculosis of Thyroid Gland, 647.
 ROBERTSON, DAVID E.: Sympathectomy, 767.
 RODMAN, J. STEWART: Chronic Cystic Mastitis, 149.
 ROYSTER, HUBERT A.: Appendicitis, 543.

S

Salivary Calculi, 979.
 Saphenous Thrombophlebitis, 682.
 Sarcoma, Intrapelvic Neurogenical, Treated by Irradiation, 305; of the Kidney of the Adult, 1028.
 SARGENT, WILLARD S.: Meningeal Hæmorrhage without Intracranial Symptoms, 462.
 SARNOFF, JACOB: A Double-Breasted Mattress Suture, 464.
 SCHWYZER, ARNOLD: Aneurism of Innominate Artery, 666; Ligation of Veins in Phlebitis, 717.
 Sclerosing Injections, Intravenous, 691.
 SCOTT, W. J. MERLE: Vasoconstrictor Spasm in Arterial Diseases, 754.
 SCRIMGER, FRANCIS A.: Bleeding Duodenal Ulcer, 587.
 SEELEY, SAM F.: Sodium Ricinoleate, 350.
 SELINGER, JEROME: Peptic Ulcer in Infants under One Year of Age, 204.
 Semilunar Cartilage, Excision of Internal, 115.
 Sepsis and Azygos Venous System, 686.
 SHEFLETT, E. LEE: Benign Tumors of the Stomach, 240.
 SHERWOOD, WALTER AIKMAN: Memoir of, 1119.
 SHIPLEY, ARTHUR M.: Appendicitis with Peritonitis, 537.
 Sigmoid, Diverticulitis of, Carcinoma of, 315.
 SINGER, HARRY A.: Perforated Peptic Ulcer of Meckel's Diverticulum, 230.
 Skin Grafting, Thiocresol in Wound Healing and in, 467.
 Skin Grafting in Cases of Severe Burns, 305.
 Skin-temperature Indications, 719.
 SMITH, ARTHUR MORTON: Perimesenteric Intra-abdominal Hernia, 292.
 SMYTH, JR., CALVIN M.: Treatment of Compound Fractures, 128.
 Sodium Ricinoleate, 350.
 Spasm, Vasoconstrictor, in Arterial Diseases, 754.
 SPEED, KELLOGG, Fracture of the Neck of Femur, 951.
 Spinal Anæsthesia, 85.
 Spirochætal Infections of Hand, 118.

INDEX

- Splenectomy, for Chronic Thrombocytopenic Purpura, Post-operative Shock Following, 447; for Movable Spleen, 317; in Purpura Hemorrhagica, 801.
- Stannoxyl in Treatment of Chronic Recurring Osteomyelitis, 1032.
- STARR, F. N. G.: Bleeding Duodenal Ulcers, 580.
- STEINBERG, BERNHARD: The Etiology of Inflammatory and Degenerative Diseases of the Appendix, 451.
- STEPHENS, HOWARD W.: Krukenberg Tumor of the Ovary, 1078.
- Sternum, Tumors of the, 830.
- STEWART, JOHN D.: Gravity Feeding in Jejunostomy, 225.
- Stomach, and Intestines, Treatment of Primary Lymphosarcoma of, 911; Benign Tumors of the, 240; Carcinoma of, 111, 588; Partial and Total Devascularization of, 179; Resection of, for Peptic Ulcer, 200.
- STONE, HARVEY B.: Saphenous Thrombophlebitis, 682.
- Stones, Removing, from Ducts within Liver, 154.
- Subclavian Aneurism, 670.
- Suture, a Double-breasted Mattress, 464.
- Sutures, Obtaining Living Fascial, 159.
- Sympathectomy, 767.
- Sympathetic Ganglionectomy, 771.
- Sympathetic Nervous System, Surgery of, 481.
- Sympathetic Neurectomy, Results Obtained by, in Raynaud's Disease, 867.
- Sympathetic Vasomotor Pathways, 744.
- Tongue and Mouth, Carcinoma of, 488.
- TOREK, FRANZ: Diffuse Suppurative Appendicitis, 549.
- Trigeminal Neuralgia, Attack by the Cerebellar Route, 787.
- TRUESDALE, PHILEMON E.: Mortality in Appendicitis, 548.
- Tuberculosis, of Segment of Duplicated Kidney, 1014; of Thyroid Gland, 625.
- Tuberculous Polyarthritis, Chronic, 1065.
- Tumors, Inoperable and Malignant, 891; Malignant, of the Kidney in Infancy and Childhood, 1017; Mediastinal, Surgical Treatment of, 830; of the Small Intestine, 269; of the Sternum, 830; of the Stomach, Benign, 240.

U

- Ulcer, Duodenal Hæmorrhagic, 581; Duodenal, the Choice of Surgical Procedures for, 258; Gastrojejunal, Advanced, 250; of Meckel's Diverticulum, Perforated, 230; Peptic, Experimental, 155; Peptic, in Infants under One Year of Age, 204; Peptic, Resection of the Fundus of the Stomach for, 200; Peptic, the Vagus Nerve and Its Relation to, 184; Post-pyloric, Therapeutic Management of, 1036.
- Ulcers, Peptic, Recurrent Perforation of, 184.
- Ureter, Hernia of the, 575.
- Ureteral Obstruction, 156.
- Urinary Tract, Calculi in, 133.

T

- Tendon Biceps, Avulsion of, 114.
- Temperature, Indications of Skin, 719.
- Thiocresol in Wound Healing and in Skin Grafting, 467.
- Thorax, Acute Empyæma of, 987.
- Thrombophlebitis, Saphenous, 682.
- Thumb, Plastic Repair of Injury to, 110.
- Thyroid, Lingual, 973.
- Thyroid Gland, Tuberculosis of, 625.
- Thyroidectomy, Paralysis Abductor, Temporary Bilateral, Tetany Following, 864.
- TINKER, MARTIN B.: Tuberculosis of the Thyroid Gland, 646; Results of Sympathetic Ganglionectomy, 784.

V

- Vagus Nerve and Its Relation to Peptic Ulcer, the, 184.
- Vascular Diseases, Peripheral, 733.
- Vasoconstrictor Spasm in Arterial Diseases, 754.
- Vasomotor Pathways, Sympathetic, 744.
- VAUGHAN, ROGER T.: Perforated Peptic Ulcer of Meckel's Diverticulum, 230.
- VEAL, J. ROSS: The Prediction of Hæmorrhage in Obstructive Jaundice by the Sedimentation Rate, 385.
- Veins, Therapeutic Ligation of, after Traumatic Lesions of Arteries, 1103.
- Venous System, Azygos, and Sepsis, 686.

INDEX

W

- WALTERS, WALTMAN: The Choice of Surgical Procedures for Duodenal Ulcer, 258; Tuberculosis of Segment of Duplicated Kidney, 1014.
- WARFIELD, J. OGLE: A Study of Mesenteric Cysts, 329.
- WARTHEN, HARRY J.: Chronic Obliterative Appendicitis, 515.
- WEEKES, CARNES: Lingual Thyroid, 973.
- WHITE, RICHARD JOSEGH, AND OWEN, MAY: Note on the Etiology of Acute Pancreatitis, 470.
- WHITE, WILLIAM CRAWFORD: Fracture of Epiphysis of the Head of the Femur, 313.
- WHITMAN, ARMITAGE: Surgical Possibilities in the Treatment of Anterior Poliomyelitis, 1049.
- WILLIS, CHARLES: Penetrating Wounds of the Abdomen, 161.

- WOLFSON, WILLIAM L., AND MORRIS, J. CLURMAN: A Cork Adjuvant to the Murphy Button, 478.
- Wound Healing, Thiocresol in, and in Skin Grafting, 467.
- Wounds, Penetrating, of the Abdomen, 161.
- WRIGHT, ROBERT B.: Fat Embolism, 75.

X

- X-ray, When Should Irradiation Precede Operation or Be Employed without Operation?, 882.
- X-ray Diagnosis of Acute Intestinal Obstruction without the Use of Contrast Media, 368.

Z

- ZINNINGER, MAX M.: The Surgical Treatment of Active Cholecystitis, 406.